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Tampa Electric Company Big Bend Unit 4

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Table 5-71. Mean abundance and relative composition of all RIS and non-RIS invertebrate meroplankton reported from select collections made in the intake canal (Station A) of the Big Bend Powerplant from March to October 1979[a] (Sheet 1 of 2)

Taxon	Mean number per cubic meter	Percent of total
Pinnixa sayana	15.231	34.77
Eurypanopeus depressus	8.120	18.54
Hexapanopeus angustifrons	3.995	9.12
Upogebia affinis	3.359	7.67
Menippe mercenaria[b]	2.047	4.67
Unidentified Xanthidae	1.340	3.06
Balanus spp.	1.114	2.54
Rhithropanopeus harrisii	1.069	2.44
Polyonyx gibbesi	0.886	2.02
Pinnixa chaeopterana	0.815	1.86
Panopeus herbstii	0.750	1.71
Unidentified Brachyura	0.620	1.42
Alpheidae sp. A	0.591	1.35
Uca spp.	0.551	1.26
Unidentified Pinnotheridae	0.536	1.22
Neopanope texana	0.406	0.93
Polychaeta	0.278	0.63
Unidentified grapsizoea	0.256	0.58
Palemonetes pugio/vulgaris	0.245	0.56
Sesarma reticulatum	0.235	0.54
Ogyrides limicola	0.219	0.50
Pinnotheres maculatus	0.204	0.47
Hippolyte spp.	0.101	0.23
Aegathoa sp.	0.088	0.20
Gastropod	0.085	0.19
Sesarma cinereum	0.078	0.18
Callianassa sp. D	0.070	0.16
Palaemonetes spp.	0.064	0.15
Periclimenes spp.	0.061	0.14
Pagurus longicarpus	0.042	0.10
Ambidexter symmetricus	0.034	0.08
Unidentified Porcellanidae	0.033	0.08
Paguridae sp. A	0.033	0.08
Penaeus duorarum[b]	0.033	0.08
Unidentified Caridea	0.033	0.08
Alpheidae sp. D	0.026	0.06
Alpheidae sp. B	0.023	0.05
Portunidae sp. B	0.021	0.05
Callianassa sp. A	0.019	0.04
Unidentified decapod	0.019	0.04
Callianassa sp. B	0.016	0.04
Persephone mediterranea	0.009	0.02

Note: See abbreviation and footnotes at end of table.

Table 5-71. Mean abundance and relative composition of all RIS and non-RIS invertebrate meroplankton reported from select collections made in the intake canal (Station A) of the Big Bend Powerplant from March to October 1979[a] (Sheet 2 of 2)

Taxon	Mean number per cubic meter	Percent of total
Alpheidae sp. E	0.009	0.02
Unidentified Alpheidae	0.009	0.02
Naushonia sp.	0.007	0.02
Pilumnus spp.	0.005	0.01
Euceramus praelongus	0.003	0.01
Petrolisthes spp.	0.003	0.01
Lolliguncula brevis	0.003	0.01
Limulus polyphemus	0.003	0.01
Echinodermata	0.002	0.01
Unidentified Paguridae	0.002	0.01
Pagurus annulipes	0.002	0.01
Unidentified Callianassidae	0.002	0.01
Pagurus pollicaris	0.001	0.01
Brachyura sp. B	0.001	0.01
Brachyura sp. A	0.001	0.01
Callianassa sp. C	0.001	0.01
Pinnotheres sp. A	0.001	0.01
Unidentified Albuneidae	0.001	0.01
Palaemonetes intermedius	0.001	0.01
Sicyonia sp.	0.001	0.01
Trachypenaeus sp.	0.001	0.01
Bivalvia	0.001	0.01
Paguridae sp. B.	0.001	0.01

Abbreviation: RIS = representative important species.

[a]Adapted from Phillips and Blanchet (1980b).
[b]RIS taxon.

Table 5-78. Macroinvertebrate taxa reported from impingement studies conducted at the Big Bend Powerplant during 1972-1975[a]

Mollusca	
Modiolus demissus	*Cyrtopleura costata*
Crassostrea virginica	*Lolliguncula brevis*
Arthropoda	
Limulus polyphemus	*Portunus gibbesii*
Squilla empusa	*Pagurus* spp.
Penaeus duorarum	*Petrolisthes armatus*
Penaeus setiferus	*Eurypanopeus depressus*
Trachypeneus constrictus	*Hexapanopeus angustifrons*
Palaemonetes intermedius	*Menippe mercenaria*
Alpheus armillatus	*Neopanope texana*
Alpheus heterochaelis	*Panopeus herbstii*
Unidentified shrimp	*Sesarma cinereum*
Upogebia affinis	*Sesarma reticulatum*
Callinectes sapidus	*Metoporhapsis calcarata*
	Insecta
Chordata	
Molgula manhattensis	*Styela plicata*

[a]Adapted from Tampa Electric Company (1975a).

Table 5-81. Seasonal occurrence of macroinvertebrate taxa reported from impingement collections made at the Big Bend Powerplant from January 1976 to March 1977[a]

Taxon	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Jan.-March
Aurelia aurita	X	X	X	X	
Chrysura quinquecirrha			X	X	X
Aplysia willcoxi		X			
Lolliguncula brevis	X	X	X	X	X
Squilla empusa	X	X		X	X
Limulus polyphemus	X	X	X	X	X
Penaeus duorarum	X	X	X	X	X
Trachypenaeus constrictus	X	X		X	X
Alpheus heterochaelis	X	X		X	X
Upogebia sp.		X			
Petrolisthes armatus	X			X	X
Petrolisthes sp.			X	X	
Pagurus longicarpus				X	X
Portunus gibbesii	X	X	X	X	X
Portunus sp.			X	X	
Callinectes ornatus	X	X			
Callinectes sapidus	X	X	X	X	X
Callinectes sp.			X	X	
Menippe mercenaria	X	X	X	X	X
Hexapanopeus angustifrons		X	X		
Neopanope texana texana	X	X	X	X	X
Eurypanopeus depressus	X	X	X	X	X
Panopeus herbstii	X	X	X	X	X
Sesarma cinerium	X	X	X	X	X
Sesarma reticulatum	X	X	X	X	X
Libinia dubia	X		X		X
Molgula sp.	X	X	X	X	X

[a]Adapted from Peekstok, Page, and Haynes (1977).

Table 5-84. Non-RIS macroinvertebrate taxa reported from Big Bend seine, trawl, and impingement collections made from March 1979 to February 1980[a] (Sheet 1 of 2)

Taxon	Collections Seine	Collections Trawl	Collections Impingement
Aurelia aurita Moon jelly			X
Chrysaora quinquecirrha Sea nettle			X
Polinices duplicatus Moon snail		X	
Busycon contrarium Lightning whelk		X	
Melongena corona Crown conch	X	X	
Fasciolaria illium hunteria Banded tulip		X	
Oliva sayana Lettered olive		X	
Lollinguncula brevis Brief squid	X	X	X
Limulus polyphemus Horseshoe crab	X	X	X
Squilla empusa Mantis shrimp		X	X
Trachypenaeus constrictus Penaeid shrimp		X	X
Palemonetes pugio Grass shrimp	X	X	X
Pagurus longicarpus Hermit crab	X	X	
Pagurus pollicaris Hermit crab	X	X	
Pagurus sp. Hermit crab	X	X	
Hapatus pudibundus		X	
Persephona aquilonaris Purse crab		X	
Portunus gibbesii Portunid crab	X	X	X
Hexanopeus angustifrons Xanthid crab			X
Hexanopeus sp. Xanthid crab			X
Neopanope texana Xanthid crab		X	X
Eurypanopeus depressus Xanthid crab	X	X	X

Note: See abbreviation and footnote at end of table.

Table 5-84. Non-RIS macroinvertebrate taxa reported from Big Bend seine, trawl, and impingement collections made from March 1979 to February 1980[a] (Sheet 2 of 2)

Taxon	Collections		
	Seine	Trawl	Impingement
Panopeus herbstii Xanthid crab			X
Unidentified xanthid Xanthid crab		X	X
Sesarma cinerium Friendly crab			X
Sesarma sp.			X
Pinnixa chaetopterana Commensal crab		X	
Libinia dubia Spider crab		X	X
Luidia clathrata Sea star		X	
Molgula sp. Tunicate		X	X

Abbreviation: RIS = representative important species.

[a]Adapted from Comp (1980).

Table 5-104. Fish taxa reported from impingement studies conducted at the Big Bend Powerplant during 1972-1975[a]

Dasyatis sayi	*Oligoplites saurus*
Gymnura micrura	*Selene vomer*
Unidentified rajid	*Lutjanus griseus*
Elops saurus	*Diapterus plumieri*
Callechelys sp.	*Eucinostomus argenteus*
Ophichthus gomesi	*Eucinostomus gula*
Brevoortia patronus	*Orthopristis chrysoptera*
Brevoortia sp.	*Lagodon rhomboides*
Dorosoma cepedianum	*Bairdiella chrysoura*
Harengula jaguana	*Cynoscion arenarius*
Opisthonema oglinum	*Cynoscion nebulosus*
Anchoa hepsetus	*Leiostomus xanthurus*
Anchoa mitchilli	*Menticirrhus americanus*
Synodus foetens	*Menticirrhus saxatilis*
Arius felis	*Menticirrhus* sp.
Bagre marinus	*Micropogon undulatus*
Opsanus beta	*Pogonias chromis*
Porichthys porosissimus	*Sciaenops ocellata*
Gobiesox strumosus	*Chaetodipterus faber*
Ogcocephalus nasutus	*Mugil cephalus*
Urophycis floridanus	*Hypsoblennius hentzi*
Ophidion holbrooki	*Peprilus alepidotus*
Hyporhamphis unifasciatus	*Prionotus scitulus*
Strongylura timucu	*Prionotus tribulus*
Fundulus similis	*Paralichthys albigutta*
Membras martinica	*Achirus lineatus*
Menidia beryllina	*Trinectes maculatus*
Hippocampus erectus	Unidentified soleid
Syngnathus louisianae	*Symphurus plaguisa*
Syngnathus spp.	*Alutera scripta*
Caranx bartholomaei	*Monacanthus hispidus*
Caranx hippos	*Lactophrys quadricornis*
Caranx latus	*Sphoeriodes nephelus*
Chloroscombrus chrysurus	*Chilomycterus schoepfi*
Hemicaranx amblyrhynchus	*Diodon holacanthus*

[a]Adapted from Tampa Electric Company (1975a).

Table 5-106. Seasonal occurrence of fish taxa reported from impingement collections made at the Big Bend Powerplant from January 1976 to March 1977[a] (Sheet 1 of 2)

Taxon	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Jan.-March
Sphyrna tiburo				X	
Dasyatis americana			X		
Dasyatis sayi		X			
Gymnura micrura	X				X
Rhinoptera bonasus					X
Elops saurus					X
Ophichthus gomesi					X
Harengula jaguana		X		X	X
Opisthonema oglinum	X		X	X	X
Anchoa hepsetus				X	X
Anchoa mitchilli	X	X	X	X	X
Synodus foetens	X				
Arius felis	X		X	X	X
Bagre marinus				X	
Opsanus beta	X	X	X	X	X
Porichthys porosissmus	X				
Gobiesox strumosus	X	X	X		
Urophycis floridanus					X
Hyporhamphus unifasciatus	X	X			
Strongylura timucu					X
Cyprinodon variegatus					X
Lucania parva		X			
Membras martinica	X			X	X
Menidia beryllina	X	X			X
Hippocampus erectus	X	X		X	X
Syngnathus louisianae					X
Syngnathus scovelli				X	
Caranx hippos					X
Chloroscombrus chrysurus	X	X	X	X	X
Hemicaranx amblyrhynchus			X	X	
Oligoplites saurus			X	X	
Selene vomer			X	X	
Diapterus plumieri	X			X	
Eucinostomus argenteus	X	X	X	X	X
Eucinostomus gula	X	X	X	X	X
Orthopristis chrysoptera		X	X	X	X
Archosargus probatocephalus			X		
Lagodon rhomboides	X	X	X	X	X
Bairdiella chrysoura	X	X	X	X	X
Cynoscion arenarius	X	X	X	X	X

Note: See footnote at end of table.

Table 5-106. Seasonal occurrence of fish taxa reported from impingement collections made at the Big Bend Powerplant from January 1976 to March 1977[a] (Sheet 2 of 2)

Taxon	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Jan.-March
Cynoscion nebulosus		X	X	X	X
Leiostomus xanthurus		X			
Menticirrhus americanus		X			
Menticirrhus saxatilis		X		X	X
Micropogon undulatus		X			
Sciaenops ocellata	X	X		X	X
Chaetodipterus faber	X	X	X	X	X
Mugil cephalus		X			
Astroscopus y-graecum		X		X	
Hypsoblennius hentzi	X			X	X
Bathygobius soporator			X		
Prionotus scitulus	X	X	X	X	X
Prionotus tribulus	X	X		X	X
Achirus lineatus	X	X	X	X	X
Trinectes maculatus			X	X	X
Symphurus plagiusa	X	X	X	X	X
Monocanthus hispidus	X	X		X	X
Acanthostracion quadricornis					X
Sphoeroides nephalus	X	X		X	X
Chilomycterus schoepfi	X	X	X	X	X

[a]Adapted from Peekstok, Page, and Haynes (1977).

Table 5-107. Non-RIS fish taxa reported from Big Bend seine, trawl, and impingement collections made from March 1979 to February 1980[a] (Sheet 1 of 4)

Taxon	Collections		
	Seine	Trawl	Impingement
Carcharhinus limbatus Blacktip shark			X
Dasyatis americana Southern stingray	X	X	
Dasyatis sayi Bluntnose stingray			X
Gymnura micrura Smooth butterfly ray		X	X
Rhinoptera bonasus Cownose ray		X	X
Myrophis punctatus Speckled worm eel			X
Ophichthus gomesi Shrimp eel			X
Brevoortia smithi Yellowfin menhaden	X	X	X
Dorosoma petenense Threadfin shad	X		X
Opisthonema oglinum Atlantic thread herring	X	X	X
Anchoa hepsetus Striped anchovy	X	X	X
Synodus foetens Inshore lizardfish	X		
Arius felis Sea catfish	X	X	X
Bagre marinus Gafftopsail catfish		X	X
Opsanus beta Gulf toadfish		X	X
Porichthys porosissimus Atlantic midshipman		X	
Gobiesox strumosus Skilletfish			X
Urophycis floridanus Southern hake		X	
Hyporhamphus unifasciatus Halfbeak	X		
Strongylura notata Redfin needlefish	X		
Strongylura timucu Timucu	X		
Cyprinodon variegatus Sheepshead minnow	X		

Note: See abbreviation and footnote at end of table.

Table 5-107. Non-RIS fish taxa reported from Big Bend seine, trawl, and impingement collections made from March 1979 to February 1980[a] (Sheet 2 of 4)

Taxon	Collections		
	Seine	Trawl	Impingement
Floridichthys carpio Goldspotted killifish	X		
Fundulus grandis Gulf killifish	X		
Fundulus similis Longnose killifish	X		
Membras martinica Rough silverside	X		
Hippocampus erectus Lined seahorse		X	X
Hippocampus zosterae Dwarf seahorse	X		
Syngnathus louisianae Chain pipefish	X		X
Syngnathus scovelli Gulf pipefish		X	
Centropomus undecimalis Snook	X	X	X
Diplectrum formosum Sand perch		X	
Caranx hippos Crevalle jack			X
Chloroscombrus chrysurus Atlantic bumper	X	X	X
Hemicaranx amblyrhynchus Bluntnose jack			X
Oligoplites saurus Leatherjacket	X		
Selene vomer Lookdown			X
Trachinotus falcatus Permit	X		
Diapterus plumieri Striped mojarra	X	X	X
Eucinostomus argenteus Spotfin mojarra	X	X	X
Eucinostomus gula Silver jenny	X	X	X
Eucinostomus lefroyi Mottled mojarra	X	X	
Gerres cinereus Yellowfin mojarra	X		
Orthopristis chrysoptera Pigfish	X	X	X

Note: See abbreviation and footnote at end of table.

Table 5-107. Non-RIS fish taxa reported from Big Bend seine, trawl, and impingement collections made from March 1979 to February 1980[a] (Sheet 3 of 4)

Taxon	Collections Seine	Trawl	Impingement
Archosargus probatocephalus Sheepshead	X	X	
Lagodon rhomboides Pinfish	X	X	X
Cynoscion arenarius Sand seatrout		X	X
Leiostomus xanthurus Spot	X	X	X
Menticirrhus americanus Southern kingfish	X	X	X
Menticirrhus saxatilis Northern kingfish	X		X
Micropogon undulatus Atlantic croaker	X	X	
Sciaenops ocellata Red drum	X	X	X
Chaetodipterus faber Atlantic spadefish	X	X	X
Tilapia sp. Tilapia	X		
Mugil cephalus Striped mullet	X	X	X
Mugil trichodon Fantail mullet	X		
Astroscopus y-graecum Southern stargazer	X		X
Hypsoblennius hentzi Feather blenny		X	X
Microgobius gulosus Clown goby		X	
Prionotus scitulus Leopard searobin	X	X	X
Prionotus tribulus Bighead searobin	X	X	X
Ancylopsetta quadrocellata Ocellated flounder		X	
Etropus crossotus Fringed flounder		X	
Paralichthys albigutta Gulf flounder	X	X	X
Achirus lineatus Lined sole	X	X	X
Trinectes maculatus Hogchoker	X	X	X

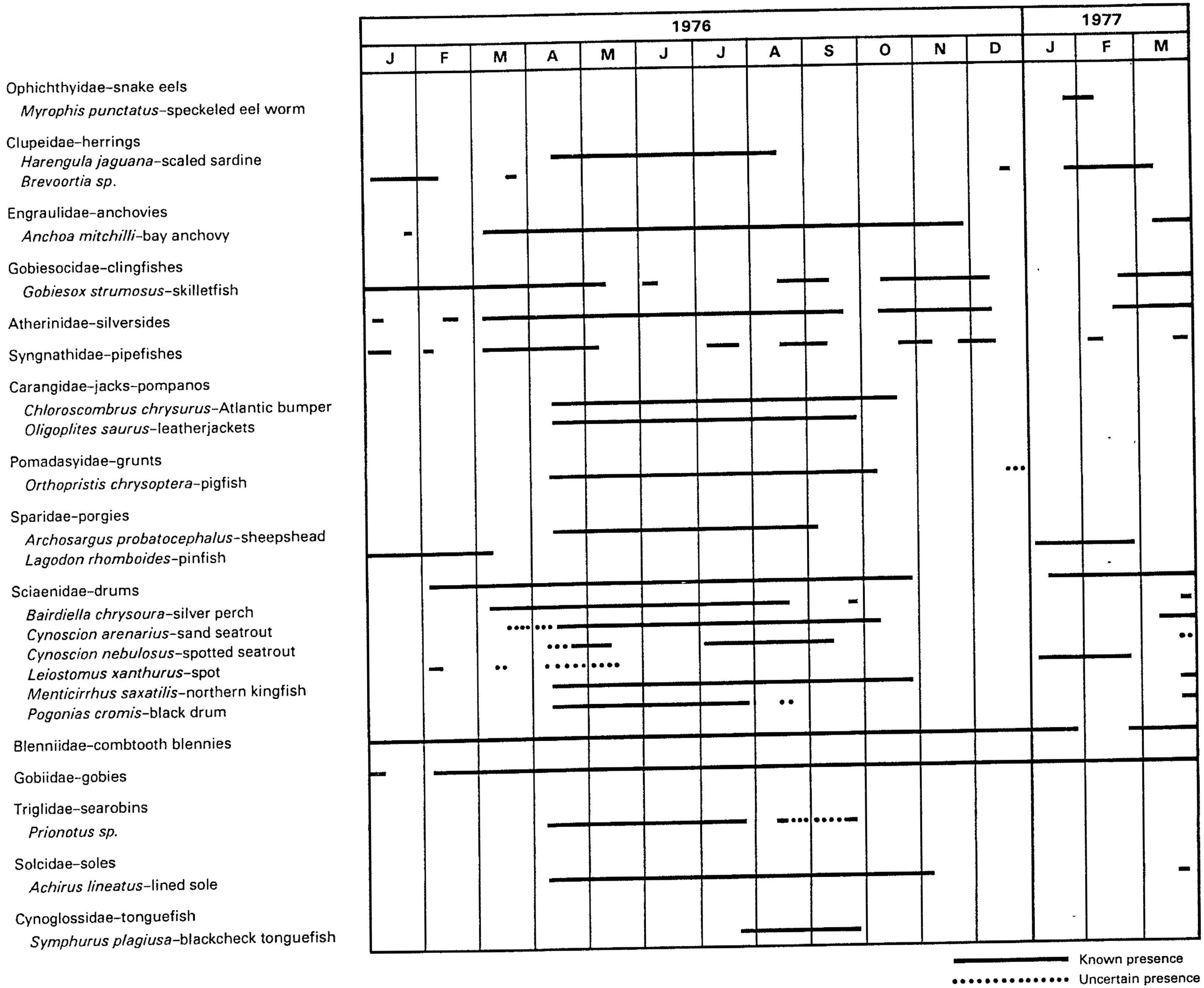
Note: See abbreviation and footnote at end of table.

Table 5-107. Non-RIS fish taxa reported from Big Bend seine, trawl, and impingement collections made from March 1979 to February 1980[a] (Sheet 4 of 4)

Taxon	Collections: Seine	Trawl	Impingement
Symphurus plagiusa Blackcheek tonguefish	X	X	X
Aluterus schoepfi Orange filefish			X
Monacanthus hispidus Planehead filefish	X		X
Lactophrys quadricornis Scrawled cowfish	X	X	X
Sphoeroides nephelus Southern puffer		X	X
Chilomycterus schoepfi Striped burrfish		X	X

Abbreviation: RIS = representative important species.

[a]Adapted from Comp (1980).



Source: Phillips et al. (1977).

Figure 5-23. Seasonal occurrence of fish larvae in the Big Bend area during 1976-1977.

involves routing them to surface waters rather than allowing them to percolate into the ground water. Such treatment, however, would defeat the purpose of the existing treatment facilities and could increase the concentrations of the above elements in surface waters.

The potential potable water supply at the Big Bend site is the underlying Floridian aquifer. It is conservatively estimated that less than 0.5 gal/min will seep into the Floridan aquifer as a result of the operation of the existing wastewater-treatment system; hence, no impact on the water quality of the Floridan aquifer is expected. Moreover, the general direction of flow in the Floridan aquifer at the Big Bend site is westerly. Any well downstream of the wastewater-treatment system would have to be located between the treatment facilities and Hillsborough Bay on property owned by the Applicant. In view of this fact, TECO has requested a variance (Tampa Electric Company 1981b) from the Florida water-quality standards for the concentrations of chromium, selenium, mercury, arsenic, and cadmium in discharges from the wastewater pond and sprayfield system.

6.3.3.2.2.6 Coal Pile

Coal-pile leachates generally have low pH values and high concentrations of iron, SO_4, and several trace metals. Since the peninsula on which the plant is sited is dredged material, the ground water beneath the coal pile is bay water. The chemical impact of the additional amount of leachate on the intruding bay water will have to be judged in terms of the quality of the ambient ground water and the amount of leachate generated by the proposed expansion of the existing coal pile, and this is difficult to predict (Tampa Electric Company 1980b).

6.3.3.3 Aquatic Ecology

6.3.3.3.1 Thermal Effects

After reviewing the Applicant's Section 316 demonstration (Tampa Electric Company 1977), which was based on studies conducted at Big Bend during 1976-1977 (Section 5.3.4.4), the U.S. Environmental Protection Agency (1980) made the following assessment of thermal effects of the operation of Units 1, 2, and 3 with dilution cooling on fish and invertebrate communities in the vicinity of the powerplant:

> Net studies conducted by seining and trawling both within and outside the expected thermal plume boundaries provide data on relative abundance, species composition, and community structure of fish in Hillsborough Bay.
>
> These data indicate that seasonal variation in species composition was similar to normal expectations for the Tampa Bay region. Temperatures in Hillsborough Bay due to the heated discharge did not appear to be a factor affecting the fish community.
>
> Considering the relative abundance and seasonal variations in species composition, the thermal discharges from Big Bend Station do not appear to interfere with the spawning of fish and shellfish in the Hillsborough-Tampa Bay area.
>
> The benthic regions off-shore of Apollo Beach and the Big Bend industrial site presently feature a sandy substrate of low organic

content, mixed with moderate to low amounts of silt and clay. The shoreline can be viewed as relatively high-energy beaches with depths quickly grading to a norm of 9-12 feet (2.7-3.7 meters). Seagrass is not now characteristic of the benthic environment and the only remnants of the shallow mangrove areas prevalent prior to the filling of Apollo Beach and the Big Bend industrial site are found in some areas of the northern embayment behind Apollo Beach.

Thermal impacts on the community of benthic organisms were intensively investigated at stations within and outside the thermal plume. Approximately 250 acres (101 ha), generally within one-half mile (0.8 km) of the point of discharge, are subject to slight to moderate impacts from the thermal discharge. Compared to non-thermal stations, stations in this area showed a marked reduction in species diversity and abundance. In addition, start-up of Unit 3 in May 1976 appeared to add to the stress condition and to cause changes in the benthic community such as reduced species diversity and abundance. Outside of the area within one-half mile of the place of discharge (POD), the benthic community appeared unaffected by increased temperature. Plume data indicated that because of thermal stratification much of the benthic community was spared exposure to excessive temperatures. In areas outside the one-half mile radius, indices of species diversity and abundance indicate little discernible effects of temperature. Sediment quality appeared as the primary factor affecting the distribution of macroinvertebrates.

With few exceptions, benthic data indicate that both the northern and southern embayments are moderately stressed in selected areas by reasons not directly attributable to thermal discharges. Both embayments tend to feature a benthic community more indicative of dead-end waterways. Thermal perturbations appeared in a shallow area in close proximity to the plant. Presently, the benthic community may be expressing effects of solar radiation and possible earlier thermal effects prior to modifications to the plant discharge. Considering results of other benthic studies in Tampa Bay, species richness and abundance appeared comparable or greater for the Big Bend area.

Severe thermal impacts from the Big Bend Station discharge were limited to the discharge canal, an area of about 10 acres (4 ha). The results of the benthic macroinvertebrate studies demonstrate the canal was severely stressed by high temperatures. This is most clearly shown by the kinds and numbers of benthos present. Since these organisms generally feature a lack of mobility and varied sensitivity to stresses, they are good indicators of long term environmental effects. The benthic community in the canal features a number of thermally tolerant species, including Nereis succinea among others; species which are not thermally tolerant have largely succumbed and have been replaced. The present community exhibits a high species diversity, high equitability, low faunal density, and a small number each of a number of species, indicative of a "pioneering" community in the discharge canal. Additional elevation of temperatures in the plume areas of Hillsborough Bay may be expected to result in an expansion of this "pioneering," thermally tolerant community into other benthic areas incurring excessive temperatures.

Based on this assessment of the thermal effects from the operation of Units 1, 2, and 3 with dilution assistance, the U.S. Environmental Protection Agency (1980) determined that

> . . . the present thermal discharge from the Big Bend Station is not causing an unacceptable adverse impact in Hillsborough Bay. Maintenance of heated discharge temperatures at, or below, present levels will continue to provide for the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on the receiving body of water, Hillsborough Bay. Tampa Electric Company's 316 (a) Demonstration is, therefore, accepted for the existing facilities at the Big Bend Station. Modifications to the discharge structures implemented prior to startup of Unit 3 have succeeded in minimizing adverse thermal impacts in the northern embayment and this area is no longer subject to unacceptable thermal impacts.

The U.S. Environmental Protection Agency (1980) also determined, however, that

> . . . the location and capacity of the cooling water intake structures, including the dilution pump system, are the major factors causing an unacceptable level of entrainment and do not reflect the best technology available for minimizing adverse environmental impact.

The Applicant responded to this determination with a proposal to terminate use of the dilution cooling system and to provide for studies to assess the biological and associated thermal consequences of such action.

Retirement of the dilution pump system would reduce the withdrawal capacity of the Big Bend facility by 36 percent and would theoretically effect a proportional reduction in the level of entrainment. The EPA Regional Administrator viewed the Applicant's proposal as a means to establish a new basis from which to reassess the impact of entrainment on Hillsborough Bay.

The EPA reviewed the results of the Applicant-sponsored thermal and biological studies (Mahadevan et al. 1980; Tampa Electric Company 1980c) and developed a Tentative Finding and Determination (U.S. Environmental Protection Agency 1981a), which are provided below.

> The Big Bend Station operates three fossil fueled generating units with a combined rated capacity of approximately 1336 megawatts (gross). However, due to design deficiencies, the units in 1979 were limited to a combined rated capacity of approximately 1105 MW (hourly gross).
>
> Based on plant design information, operation of Units 1, 2 and 3 at the reduced operating capacity of 1105 MW should produce a condenser flow with a maximum temperature rise of 7.7°C (13.9°F). When dilution and condenser cooling flows are combined, a normal design maximum temperature rise of 5.1°C (9.1°F) would be expected

at the point of discharge. However, as shown by temperature records, temperature rises above these values do occur. For example, an average temperature rise of 7.2°C (13.0°F) was attained at the point of discharge during the months of July and August 1980. Also, maximum daily temperatures of 9.5°C (17.0°F) were frequently observed. During the July-August period, the average capacity factor for Units 1, 2 and 3 was 66 percent of the reduced maximum base load and 1105 MW or 55 percent of the facility's maximum design capacity of 1336 MW.

For 1979, the daily operating load for Units 1, 2 and 3 averaged 639 MW (48 percent of the maximum rated capacity). The maximum sustained station load for a 24-hour period was reported at 1074 MW. In the foreseeable future, plant modification could provide for a station capacity of 1275 MW with instantaneous peaks of 1336 MW, the design capacity of the facility. From 1976 to 1980, plant modifications have resulted in an increase in generating capacity of 1092 to 1130 MW for Units 1, 2 and 3.

From May through December 1979, TECO conducted an EPA approved biological study in the area of Hillsborough Bay receiving heated discharges from the Big Bend facility. The objective of the 8-month study was to evaluate changes in the benthic macroinvertebrate community relative to increased discharge temperatures caused by cessation of the dilution assist cooling system. Shut-down of the dilution assist cooling system occurred August 3, 1979.

Intake temperatures of the Big Bend facility were considered representative of ambient conditions. During 1979, reported daily intake temperatures peaked during the months of July and August when water temperatures ranged from 29.4°C (85.0°F) to 32.2°C (90.0°F) and yielded an average of 30.5°C (86.9°F) for the 2 months. Correspondingly, water temperatures at the point of discharge ranged from 32.8°C (91.0°F) to 47.2°C (117.0°F) with an average of 37.6°C (99.7°F).

During the course of the benthic macroinvertebrate investigation, the monitoring of plume configuration under field conditions was not required. Instead, results of thermal modeling efforts conducted by the company provided a comparison of average plume conditions relative to temperatures attributable to operation of the dilution assist cooling system. With Units 1, 2 and 3 at 64 percent of maximum rated capacity, the following table illustrates the expected surface dimension of the plume with and without operation of the dilution pump.

Isotherm (ΔT^oC)	Area Hectares (Acres) With Dilution Pump	Area Hectares (Acres) Without Dilution Pump
1°	769 (1900)	923 (2280)
2°	340 (840)	437 (1080)
3°	109 (269)	219 (541)
4°	42 (104)	109 (269)
5°	5 (12)	55 (136)
6°	4 (10)	31 (77)
7°	no data	19 (47)
8°	no data	11 (27)
9°	no data	6 (15)

Because the average station load during 1979 was only 48 percent of the maximum rated capacity of the facility, the actual areal extent of the plume configuration should be less than projected by modeling results at 64 percent plant capacity.

Based upon results of the thermal modeling studies reported by TECO, heated effluent from the Big Bend Station will provide for a thermally stratified water column in Hillsborough Bay. At a distance of 300 m (328 yd) and 360 m (394 yd) seaward of the point of discharge, the plume is expected to detach from the bottom when Units 1, 2 and 3 are operated without dilution and at 64 and 100 percent of the rated capacity, respectively. The bottom area in direct contact with the plume would be approximately 5ha (12.4a) to 7ha (17.3a).

Compared to results of a 1976 investigation reported in a previously submitted 316(a) demonstration of the Big Bend facility, a general decline in the quality of the benthic macroinvertebrate community has occurred. However this decline, measured in terms of decreases in animal abundance and species diversity, appeared as an areawide trend in the Tampa-Hillsborough Bay and was not limited to the thermally affected region associated with the Big Bend facility.

Adverse impacts related to elevated temperatures following the shut-down of the dilution pump system appeared concentrated in an area adjacent to the facility's point of discharge. A measured decrease in faunal density and species richness was observed in the benthic animal community inhabiting approximately a 7ha (17a) area adjacent to the point of discharge. A preponderance of opportunistic and pollution tolerant species characterized the variety of benthic animals inhabitating the thermally stressed area. At the time of benthic sampling, the area of impact featured bottom temperatures which ranged from a high of about 34.0°C (93.2°F) in August to a low 23.0°C (73.4°F) in December. This area of impact represented approximately a 43 percent expansion of the thermally stressed environment previously limited to the station's discharge canal. The total area of benthic habitat subject to severe thermal stress, with shut-down of the dilution pump systems, measures about 23ha (57a).

Beyond the zone of primary impact, short-term adverse faunal effects were observed, but cannot be clearly related to water temperatures associated with the shut-down of the dilution pump system or operation of the Big Bend facility. Natural cyclic variations in the benthic animal community and areawide perturbations, such as siltation effects from the Bay deepening project, could also serve to explain the apparent trends in the quality of the benthic biota.

The benthic area adjacent to the point of discharge and subject to a persistent thermal impact is generally encompassed by the bottom contact boundaries of the plume as predicted by hydrographic modeling. The projected boundaries assumed no dilution and operation of Units 1, 2 and 3 at 64 and 100 percent of the design capacity of the units. However, actual plant operation was only 55 percent of maximum capacity for the period of July and August when peak ambient temperatures occurred. In 1979 the operation of Units 1, 2 and 3 averaged 48 percent of design capacity.

The biological studies showed that the area of adverse environmental impact exceeded the bottom area in contact with the projected plume. Thus, the dimensions of the plume projected by the hydrographic model cannot be utilized with confidence to predict the area of adverse thermal impact resulting from increased generation capacity. In view of this discrepancy, a linear extrapolation, which may overestimate perhaps to worst case situations, has been utilized to describe the potential area of adverse thermal impact expected to result from the combined effects of increased generative capacity and retirement of the dilution assist pumps. Based on a linear extrapolation, actual operation of Units 1, 2 and 3 at 100 percent capacity would double the area presently determined to be adversely affected by severe thermal stress.

Operation of Units 1, 2 and 3 at the currently established load regimen and without the benefit of a dilution assisted cooling system causes adverse impacts in approximately 23ha (57a) of benthic habitat, which includes the discharge canal. Further plant modification will provide for increases in the maximum load capability of Units 1, 2 and 3 and consequent increases in discharge temperatures. Such temperature increases will necessarily expand the boundaries of the current zone of thermal impact. Assuming that Units 1, 2 and 3 attain 95 percent of their design capacity, approximately 46ha (114a) of Hillsborough Bay, including the discharge canal, 16ha (40a), is expected to suffer adverse impacts. The 46ha (114a) area predicted by linear extrapolation, while providing living space for many benthic macroinvertebrates, is nevertheless a sandy, tidal swept, high energy environment which is essentially devoid of seagrass habitat and other highly valued habitat-forming communities, i.e., hard-bottom or coral.

From this evaluation, the EPA made the following determinations:

1. The proposal to reduce the withdrawal capacity of the Big Bend facility by retiring the dilution pump system provides a new

basis upon which to reassess the impact on Hillsborough Bay of entrainment to the station.

2. The Tampa Electric Company conducted studies adequate to demonstrate biological effects of elevated discharge temperatures resulting from cessation of the dilution assisted cooling system for Units 1, 2 and 3. The study was initiated in May 1979 and continued through December 1979. The dilution pump system was shut-down on August 3, 1979. The 8-month period of study included the time during which maximum ambient temperatures would occur in Hillsborough Bay.

3. Elevated discharge temperatures resulting from cessation of the dilution pump system caused a discernible thermal impact on the benthic invertebrate community of Hillsborough Bay. The zone of adverse impact measured approximately 7ha (17a) beyond the POD and represented about a 43 percent expansion of the thermally stressed region previously restricted to the discharge canal.

4. The entrainment level at the cooling water intake structure has been reduced to an acceptable level for the purposes of Section 316(b) of the Act.

5. The expected increase in the area of adverse environmental impact due to the thermal discharge from Big Bend Units 1-3 will not cause an unacceptable impact in Hillsborough Bay. The company's 316(a) demonstration is, therefore, accepted for the existing facilities.

After reviewing the Applicant's Section 316 Demonstration for the proposed Unit 4 (Tampa Electric Company 1980c), which was based on studies conducted at Big Bend made the following assessment of the thermal effects of the combined operation of Units 1, 2, 3, and 4 without dilution assistance:

> Addition of Unit 4 will bring the maximum capacity of the Big Bend Station to a nominal 1782 MW (gross). Operation of Unit 4 is expected to average 64 percent of its maximum design capability of 445 MW (gross).
>
> The proposed method for condenser cooling for Unit 4 is once-through which is the current cooling design for Units 1 through 3. Cooling water withdrawal is via a 25 foot deep intake canal connecting to a 35 foot deep ship channel leading to Hillsborough Bay. Rate of withdrawal is 537 cfs for each unit which effects a combined cooling water requirement of 2148 cfs. Based on design information, bay water as it is circulated through the condensers will experience a temperature rise of 9.3°C (16.8°F). Based on current thermal records temperature rises frequently exceed these values.
>
> With the addition of Unit 4 to the Big Bend Station, the current heat load to Hillsborough Bay is expected to increase by approximately 33 percent. Although temperature rises at the point of discharge will remain unchanged, the added thermal load to the

bay will provide for an enlargement of benthic area presently subject to adverse effects. Based on a linear extrapolation, the operation of Units 1 through 4 without dilution assist cooling could potentially provide for an adverse impact to approximately 61ha (152a) of bay bottoms.

The operation of Units 1 through 4 without a dilution assist cooling system will potentially cause an adverse thermal impact to approximately 61ha (152a) of benthic habitat. The thermal impact, however, would not be viewed as substantial or unacceptable in terms of thermal damage to the benthic biota of Hillsborough Bay, because of the sandy, tidal swept nature of the benthic area subject to the impact and the fact that it does not represent primary benthic habitat which includes seagrass and other habitat forming community.

On the basis of this assessment, the EPA determined that:

1. The operation of Units 1 through 4 without a dilution assist cooling system will potentially cause an adverse thermal impact to approximately 61ha (152a) of benthic habitat. The thermal impact, however, would not be viewed as substantial or unacceptable in terms of thermal damage to the benthic biota of Hillsborough Bay, because of the sandy, tidal swept nature of the benthic area subject to the impact and the fact that it does not represent primary benthic habitat which includes seagrass and other habitat forming community.

2. The expected increase in the area of adverse environmental impact due to the thermal discharge from Big Bend Units 1-4 will not cause an unacceptable impact in Hillsborough Bay. The company's 316(a) demonstration is, therefore, accepted.

6.3.3.3.2 Intake Effects

The intake of cooling water into powerplant condenser systems can produce ecological impacts from (1) the impingement of large aquatic organisms on the intake screening system used to prevent fouling of the plant condenser tubes and (2) the entrainment of aquatic organisms, smaller than the mesh of the screening system, within the plant cooling system.

6.3.3.3.2.1 Impingement

The assessment of impingement impacts at Big Bend is based on the results of studies conducted in 1976-1977 (Peekstok et al. 1977; Tampa Electric Company 1977) and 1979-1980 (Comp 1980; Robinson 1980; Tampa Electric Company 1980c) as part of the Section 316(a) and (b) Demonstrations for Units 1, 2, and 3 and the proposed Unit 4, respectively.

During the first study, the traveling screens of either Unit 1 or 2 were sampled for 24 hours at approximately 2-week intervals from January 1976 to March 1977. Sixty species of fish were taken in the impingement collections during the 15-month study period (Table 5-106). Six species accounted for 86 percent of the total number of individuals impinged: Anchoa mitchilli (bay anchovy, 39 percent), Bairdiella chrysoura (silver perch, 32 percent), Lagodon rhomboides (pinfish, 5 percent), Cynoscion arenarius (sand seatrout, 4 percent), Prionotus scitulus (leopard searobin, 3 percent), and Chloroscombrus chrysurus (Atlantic bumper, 3 percent). Fish impingement rates were greatest from July to September 1976 and from January to March 1977. The species that dominated the impingement catch during these periods were B. chrysoura (July-September) and A. mitchilli (January-March). These species were also the fishes most commonly impinged throughout the 15-month study.

The seasonal abundance (by quarter) of total fishes as well as that of the dominant taxa impinged during 1976-1977 are presented in Table 6-33. Also included are the mean daily impingement rates calculated for each quarter from the results of sampling every 2 weeks during that quarter. Size-frequency data for impinged individuals of the dominant fish taxa are presented in Figures 6-37 through 6-40. From the mean daily impingement rates and the total number of operating days for each of the three generating units at Big Bend, estimates were made of impingement levels that occurred during each quarter of the study period (Table 6-34). These levels were then added to yield the total estimated annual impingement (January-December 1976 and April 1976-March 1977) occurring at the Big Bend Power Station during the study.

Twenty-seven macroinvertebrate species were taken in the biweekly impingement collections made at Big Bend in 1976-1977 (Table 5-81). Six species accounted for 87 percent of the total number of invertebrates collected during the 15-month study: Penaeus duorarum (pink shrimp, 39 percent), Callinectes sapidus (blue crab, 13 percent), Limulus polyphemus (horseshoe crab, 13 percent), Portunus gibbesii (9 percent), Lolliguncula brevis (brief squid, 7 percent), and Squilla empusa (mantis shrimp, 6 percent). Macroinvertebrate impingement rates (Tables 6-33 and 6-34) were greatest during winter (January-March 1976 and 1977) and summer (July-September 1976). The impingement of P. duorarum and L. brevis was greatest during the summer, while C. sapidus, L. polyphemus, P. gibbesii, and S. empusa were impinged in greatest numbers during the winter. Size-frequency data for impinged individuals of the dominant taxa are presented in Figures 6-41 through 6-46. With the exception of L. brevis, the dominant invertebrate taxa had high survival rates after impingement on the traveling screens.

After reviewing the Section 316(b) Demonstration for Big Bend Units 1, 2, and 3, which was based on the studies conducted during 1976-1977, the U.S. Environmental Protection Agency (1980) determined that "the reported level of impingement does not appear to be a factor causing a substantial impact to the fisheries of Hillsborough Bay." The EPA further determined that "designing and constructing the cooling water intake structures for Units 1, 2, and 3 at the Big Bend Station without provision for returning viable fish and shellfish impinged on the intake screens to the environment may not reflect the best technology available for minimizing adverse environmental impacts" and that "evaluation of mechanisms to return impinged organisms in a viable condition should be undertaken."

As part of the Section 316(a) and (b) Demonstrations to assess the potential impacts of the proposed Unit 4, an impingement study was conducted at Big Bend from March 1979 to February 1980. All organisms impinged on the traveling screens of one of the three operating units during one 24-hour period were collected once every 2 weeks for the 1-year study period. While all impinged organisms were identified and counted, more detailed analyses were conducted on those select "representative important species" (RIS) taken in the collections (Table 5-55), a detailed impact assessment was reported only for these taxa.

A total of 3,100 fish representing 52 species and 4,576 macroinvertebrates representing 20 species were taken in the 552 hours of impingement collections made during the 1-year study. The numbers of RIS fish and invertebrate taxa impinged during each 24-hour collection period from March 1979-February 1980 are presented in Table 6-35. The numbers predicted to be impinged annually at Big Bend with continuous three- and four-unit operation, based on the data collected during 1979-1980, are presented in Table 6-36. The predicted monthly impingement rates for RIS taxa with continuous four-unit operation are presented in Table 6-37.

Bay anchovies were impinged in low numbers during every month except July; however, the largest number (64 percent) were impinged from November to January, the period when large numbers were also taken in trawl collections made in the intake canal (Section 5.3.4.5). Individuals impinged during the study period ranged in size from 32 to 68 millimeters (standard length) with a mean length of 50 millimeters. The wet weights of impinged individuals ranged from 0.3 to 4.1 grams and averaged 1.5 grams over the year.

Of the RIS fish and invertebrate taxa impinged during 1979-1980, silver perch ranked second in abundance. While individuals of this species occurred in most of the 24-hour impingement collections, the largest number (71 percent), mostly juveniles, were impinged from May to July; this was the period when large numbers were also noted in trawl collections. Impinged individuals ranged from 34 to 138 millimeters (standard length) in size and from 0.9 to 65.2 grams in weight; mean values for the study year were 53 millimeters and 3.4 grams.

During 1979-1980, pink shrimp were impinged in greater numbers than any other fish or invertebrate taxon (RIS or non-RIS) at Big Bend. Individuals of this species were found in all 24-hour impingement collections made during the study year but were impinged in greatest numbers from summer through late fall, generally corresponding to the period when pink shrimp were most abundant in trawl collections made in the Big Bend area. Impinged individuals ranged from 33 to 152 millimeters in total length and 0.5 to 35.5 grams in weight; mean values were 64 millimeters (total length) and 2.8 grams, indicating that primarily juveniles were impinged during the study year.

Blue crabs were found in the impingement collections during all months of sampling but generally occurred in low numbers. Their impingement was greatest during January and February sampling, when 69 percent of all those taken in the 1-year study were collected. Impinged individuals ranged from 12 to 176 millimeters in carapace width and from 0.1 to 242.7 grams in weight; mean values were 48 millimeters and 17.6 grams, indicating that mostly juveniles were impinged.

The remainder of the select RIS fish and invertebrate taxa were found only rarely (scaled sardine, spotted seatrout, black drum, stone crab) or not at all (tidewater silverside) in the impingement collections made at Big Bend during 1979-1980.

A total of 2,479 non-RIS fishes representing 47 species were found in impingement collections made during 552 sampling hours of the 1-year study (Table 5-107). The five most abundant taxa were sand seatrout (Cynoscion arenarius, 1,180 individuals), Atlantic bumper (Chloroscombrus chrysurus, 246), pigfish (Orthopristis chrysoptera, 145), pinfish (Lagodon rhomboides, 133), and Gulf toadfish (Opsanus beta, 126). Sand seatrout occurred in impingement collections during most of the study year but were most abundant from September to November, when individuals were predominantly young-of-the-year, probably the result of a spring-summer spawn. This species was also the most abundant non-RIS fish collected by trawl during the 1979-1980 studies at Big Bend, occurring in relatively high abundance in the intake canal. Atlantic bumper comprised only a small portion of the impingement catch during the study until the two collections made in October, when 211 individuals, mostly young-of-the-year, were taken. Pigfish were found in the collections from April through August, with the largest numbers occurring during June and July. Pinfish were present in the collections sporadically throughout the study year; the largest numbers (64 percent) were observed from late April through May. Gulf toadfish were collected in low numbers throughout most of the study period.

A total of 2,627 non-RIS macroinvertebrates representing 17 species occurred in impingement' collections made at Big Bend during 1979-1980 (Table 5-84). The horseshoe crab was the most commonly collected species, with 1,533 individuals impinged. The portunid crab, Portunus gibbesii, accounted for 17 percent of impinged non-RIS invertebrates, while the xanthid crabs (Hexapanopeus angustifrons, Hexapanopeus sp., Neopanope texana, Eurypanopeus depressus, Panopeus herbstii, and an unidentified species) comprised approximately 9 percent of the total number of non-RIS invertebrates collected.

After reviewing the Section 316(b) Demonstration for Big Bend Unit 4, which was based on the studies conducted during 1979-1980, the U.S. Environmental Protection Agency (1981b) determined that:

1. The addition of Unit 4 (with conventional once-through cooling) to the Big Bend Station will potentially increase the current impingement effects of Units 1 through 3 by approximately 33 percent.

2. Based on the results of the Fine-Mesh Screening Prototype Studies, sufficient information was provided to determine that the fine-mesh screening of intake structures is a viable technology that will minimize entrainment effects. Furthermore, the installation of fine-mesh screens on Big Bend Units 3 and 4 will provide for entrainment effects approximately equal to the current impacts associated with the operation of Units 1, 2 and 3 with conventional intake technology. The design modification effected by the addition of fine-mesh screens at the cooling water intake for Units 3 and 4 minimizes adverse environmental impact for the purposes of Section 316(b) of the Act.

An additional benefit of using the fine-mesh screening system on the intakes of Units 3 and 4 is the expected reduction in impingement resulting from a lower screen-face velocity (0.5 fps approach velocity) than that of conventional screens (1.45 fps). Furthermore, all organisms impinged on the fine-mesh screens will be automatically washed from the screens and returned to Tampa Bay via the organism-return system (Sections 6.3.3.3.2.3 and 6.3.3.3.2.4).

6.3.3.3.2.2 Entrainment

The entrainment of meroplanktonic organisms within the cooling-water systems of the Big Bend Station was evaluated in the Section 316(a) and (b) Demonstration studies conducted during 1976-1977 (Phillips et al. 1977; Blanchet et al. 1977; Tampa Electric

Company 1977) and 1979-1980 (Phillips et al. 1980a,b; Robinson 1980, 1981; Tampa Electric Company 1980c; Section 5.3.4.3).

The entrainment of meroplankton organisms within both the condenser cooling system and the dilution pumping system was evaluated from January 1976 to March 1977. The rates of entrainment in the condenser systems of Units 1, 2, and 3 were calculated from cooling-water pumping rates and meroplankton abundance estimates. The meroplankton estimates were based on organism concentrations in samples collected at approximately 2-week intervals directly within the condenser effluent of an operating unit (Station I-1 or I-13; Figure 5-22) at the site of discharge to the discharge canal. Meroplankton abundance in the discharge samples was considered a more reliable measure of the quantity of organisms passing through the condenser cooling system than were plankton densities in samples that were routinely collected in the intake canal (Station I-6) during the study. The latter samples were obtained by towing the plankton nets obliquely through the water column in front of an operating unit.

The number of meroplankton organisms passing through the dilution pumping system, and subsequently entrained in the condenser effluent water in the discharge canal, was calculated from organism densities in samples collected approximately biweekly at dilution-pump intake and discharge locations (Stations 0-8 and I-16). Samples were collected at these stations by making plankton tows obliquely through the water column; the density data used in the entrainment calculations were averaged for the two stations.

The plant operational schedule that was followed during the study period is presented in Table 6-38. When a generating unit was operational, a constant cooling-system pumping volume of 15.2 m^3/s (537 cfs) was assumed; a constant dilution pumping rate of 25.2 m^3/s (890 cfs) was assumed when that system was operational.

Estimates of the number of meroplankton organisms entrained within the cooling-water systems of Big Bend Units 1, 2, and 3 during 1976-1977 are presented in Tables 6-39 and 6-40. The investigators noted that these represent the best possible estimates from the data collected, but were undoubtedly influenced by the high sampling variability and state-of-the-art species-identification problems that are inherent in studies of this type.

The seasonal rates at which planktonic organisms are entrained depend on the cooling-system pumping rates, which are dependent on the operating status of the various generating units, as well as on the seasonal distribution and abundance of the organisms in the vicinity of the plant intakes. Operational data for the condenser-system circulating pumps and the dilution-system pump at Big Bend during the study period are in Table 6-38. During the 1-year period from January to December 1976, the condenser-system circulating pumps were operational at 66 percent of capacity (724 of 1,098 generating-unit days). The dilution pumping system was operational at 70 percent capacity (258 of 366 pump-unit days) during this period. Pumping was below the maximum three-unit capacity during this period because the newly constructed Unit 3 did not become operational until May and because of the periodic "outage" of each of the three units throughout the year. The annual entrainment of fish eggs and larvae during 1976 amounted to 8.6×10^{10} and 2.6×10^{10} individuals, respectively, within the condenser cooling system and 1.0×10^{11} and 1.3×10^{10} individuals, respectively, within the dilution pumping system.

During the 1-year period from April 1976 to March 1977, the condenser-cooling system and the dilution system were operated at 77 and 86 percent, respectively, of capacity (847 of 1,095 generating-unit days and 313 of 365 pump-unit days). The entrainment of ichthyoplankton during this period amounted to 9.9×10^{10} and 2.7×10^{10} eggs and larvae, respectively, within the condenser cooling system and 8.9×10^{10} and 1.1×10^{10} eggs and larvae, respectively, within the dilution pumping system.

Fish eggs were entrained within the plant cooling systems during all months except January, while larvae were entrained during every month of the 15-month study. The entrainment of fish eggs within the cooling systems was greatest from March through July; the entrainment of fish larvae was greatest from March to October.

Tables 6-41 and 6-42 presented data on the relative annual entrainment of ichthyoplankton organisms, grouped by family, that occurred within the plant condenser and dilution cooling systems during 1976, as summarized by the U.S. Environmental Protection Agency (1980) from data reported by Phillips et al. (1977). The families Engraulidae and Sciaenidae accounted for, respectively, 99 and 90 percent of all eggs and larvae entrained during the 1-year period. In the assessments of entrainment impact during 1976-1977 (Phillips et al. 1977), emphasis was placed on the following taxa: the bay anchovy (Anchoa mitchilli), which was the dominant fish species taken in ichthyoplankton collections at Big Bend and is an important forage taxon; members of the drum family (Sciaenidae), which include species of commercial and sport value in the Tampa Bay area and, along with the engraulids, numerically dominated ichthyoplankton catches at Big Bend; and the scaled sardine (Harengula jaguana), a species of potential commercial value as a bait fish in the area. Estimates of the monthly entrainment of these taxa at Big Bend, based on results of the 1976-1977 studies, are presented in Tables 6-43, 6-44, and 6-45, respectively.

Eggs of the bay anchovy accounted for 34 and 29 percent of the total annual entrainment of fish eggs within the condenser cooling system and the dilution pumping system, respectively, during 1976; larvae accounted for 88 and 84 percent of the total annual entrainment in the respective cooling systems. One or both planktonic life stages were entrained within one or the other cooling system during all months except January and December 1976 and January 1977. The highest numbers of eggs were entrained from April through July; the highest numbers of larvae were entrained from April through October. These months correspond to the periods when these developmental stages are most abundant in the Big Bend area.

The eggs of various Sciaenidae comprised 65 and 69 percent of the total annual fish eggs entrained within the condenser cooling and dilution pumping systems, respectively; larvae accounted for 2 and 5 percent of the total entrainment through the respective systems during the year. Entrainment values were calculated for sciaenids tentatively identified to the genus or species level, but, because the early planktonic stages of this family present identification problems, the assessment of impacts was considered most reliable by considering the combined number of family members as a whole. Sciaenid eggs were entrained within the plant cooling systems during all months except January 1976. Larvae were entrained every month except January, February, November, and December 1976. The entrainment of both eggs and larvae was highest from March through September.

The scaled sardine accounted for 0.7 and 0.1 percent of the total entrainment of fish eggs within the condenser cooling and dilution systems, respectively, at Big Bend during 1976; larvae accounted for 0.1 and 0.4 percent of the total larvae entrained in the respective systems. The eggs and larvae of this species were entrained only during the period from April to July.

The level of entrainment for invertebrate meroplankton at Big Bend was also estimated from collections made during 1976-1977 (Table 6-40). Of the invertebrate forms taken in the collections, only planktonic stages of the decapod crustaceans were adequately sampled with the coarse mesh (363-micrometer) nets used in the study. Therefore, entrainment estimates are considered valid for only these forms.

The annual entrainment of total invertebrate meroplankton during 1976 amounted to 5.4×10^{11} individuals within the condenser cooling system and 2.5×10^{11} individuals within the dilution pumping system (Table 6-40). During the 1-year period from April 1976 to March 1977, the annual entrainment amounted to 5.5×10^{11} and 2.1×10^{11} individuals in the respective cooling systems. The entrainment of invertebrate meroplankton occurred during all months of the study but was highest from April through October.

The impact of invertebrate-meroplankton entrainment at Big Bend during 1976-1977 was assessed by Blanchet et al. (1977). The assessment concentrated primarily on the four most abundant taxa in the collections and also on the stone crab, a species that is of commercial value in the adult stage and was entrained in appreciable numbers at Big Bend.

The pinnotherid crab Pinnixa sayana was the most abundant larval invertebrate collected in the vicinity of Big Bend during 1976-1977 and was also the species that was entrained within the plant cooling systems in greatest numbers. This species accounted for 43 and 32 percent, respectively, of the invertebrate meroplankton entrained during 1976. Seasonally, entrainment was highest from March to November (Table 6-46). The porcellanid crab Polyonyx gibbesi accounted for 20 and 40 percent, respectively, of condenser and dilution pump entrainment of larval invertebrates during 1976; entrainment was high from March to November (Table 6-47). The callianassid shrimp Upogebia affinis accounted for 8 and 9 percent of condenser and dilution pump entrainment during 1976, entrainment being high from March to October (Table 6-48). The xanthid crab Neopanope texana was entrained in greatest numbers from August to October (Table 6-49) and accounted for 8 and 3 percent of the invertebrates entrained in the condenser and dilution pumping systems. The entrainment of Menippe mercenaria (stone crab) larvae accounted for approximately 1 percent each of the total invertebrates entrained in the respective cooling systems at Big Bend during 1976; entrainment was greatest from April to October (Table 6-50).

Other taxa of commercial value in the Tampa Bay area were identified from the meroplankton collections during 1976-1977. Only a relatively few individuals (24) of Penaeus duorarum (pink shrimp) were identified from the collections in the vicinity of the power plant. Accordingly, few individuals were estimated to have been entrained during the study period: from July to December, 6.9×10^6 postlarvae within the condenser cooling system and 7.3×10^5 within the dilution pumping system. A single damaged postlarva of a member of the family Penaeidae (probably Trachypenaeus or Sicyonia sp.) was collected in a discharge sample during August. On the basis of this single occurrence, 2.4×10^6 individuals were estimated to have been entrained at Big Bend during the study period. A few zoeae identified as Callinectes sp. (blue crab?) were recorded from the meroplankton collections. This species is also listed as having been entrained during August 1976 and February and

March 1977 for a total of 1.4 x 10^7 individuals entrained during the study period, all within the dilution pumping system.

With Units 1, 2, and 3 operating, maximum cooling-water flows totaling 46 m^3/s (1,610 cfs) pass through the condenser cooling systems at Big Bend. Organisms entrained within the cooling water are then exposed in the condensers to increases in water temperature as great as 7.9°C (14.1°F) above ambient. Dilution-pump flow totals 25 m^3/s (890 cfs), or 36 percent of total combined plant cooling-water flows. The U.S. Environmental Protection Agency (1980) determined that:

> In the absence of substantial information to the contrary, it is assumed that pump pressures, mechanical and physical friction in the pumps, and the 5.1°C (9.1°F) . . . thermal shock associated with mixing of the condenser flows, will produce a mortality rate of 100% of organisms entrained in the dilution system.

After evaluating the entrainment data collected during 1976-1977, the EPA concluded that:

> Entrainment of eggs and larvae of fish and shellfish through the cooling water intake structures including the dilution pump system at the Big Bend Station is of sufficient magnitude to cause unacceptable adverse environmental impact in Hillsborough Bay.

The EPA further determined that:

> The location and capacity of the cooling water intake structures at the Big Bend Station are the major factors causing this unacceptable level of entrainment and do not reflect the best technology available for minimizing adverse environmental impact.

The Applicant responded to this determination with a proposal to terminate use of the dilution-assist cooling system and to provide for studies to assess the biological and associated thermal consequences of such action.

Retirement of the dilution-pump system would reduce the withdrawal capacity of the Big Bend facility by 36 percent and would theoretically effect a proportional reduction in the level of entrainment. The EPA Regional Administrator viewed the Applicant's proposal as a means to establish a new basis on which to reassess the impact of entrainment on Hillsborough Bay.

The EPA reviewed the results of the Applicant-sponsored thermal and biological studies (Mahadevan et al. 1980; Tampa Electric Company 1980c) and determined (U.S. Environmental Protection Agency 1981a) that:

> The reduction in capacity of the cooling-water intake effected by elimination of the dilution-assist pumps potentially represents a 36-percent reduction in entrainment losses. The entrainment level at the cooling-water intake structure has been reduced to an acceptable level for the purposes of Section 316(b) of the Act (Federal Water Pollution Control Act, 33 U.S.C. 1326). The expected increase in the area of adverse environmental impact due to the thermal discharge from Big Bend Units 1, 2, and 3 (without dilution assistance) will not cause an unacceptable impact in Hillsborough Bay.

The Applicant's 316(a) demonstration is, therefore, accepted for the existing facilities.

1979-1980 ↓ e.n

Condenser entrainment was also evaluated from data collected during the 1979-1980 Big Bend Aquatic Ecology Studies. These studies were conducted to gather information for preparation of the Sections 316(a) and (b) Demonstrations for Units 1 through 4. The entrainment rates of a select group of RIS (Table 5-55) occurring with existing Units 1, 2, and 3 were extrapolated to that projected for four-unit operation. In contrast to the 1976-1977 studies, estimates of the number of organisms entrained in the plant cooling systems were based on meroplankton densities in samples collected biweekly with oblique plankton tows in the water column at intake Station A (Tables 5-56 through 5-63 and 5-68 and 5-69). Collections were also routinely made within the discharge effluent of one of the operating units (Station B) by allowing the nets to passively fish in the effluent current (the method also used during sampling at this station during the 1976-1977 studies). However, observations made during sampling at this station cast doubt on the reliability of this sampling method. (Water turbulence and relatively low current velocities may have precluded accurate measurements of water volume flow through the nets.) From these biweekly meroplankton-density estimates and cooling-water flow rates, monthly rates of maximum potential entrainment were projected for the combined operation of Units 1 through 4 at 100 percent flow capacity (Table 6-51).

After evaluating the Section 316b Demonstration for Unit 4, which was based on studies conducted during 1979-1980, the U.S. Environmental Protection Agency (1981b) determined that the Applicant's analyses fail to demonstrate the adequacy of conventional once-through cooling to minimize entrainment impacts. The EPA further concluded that:

> All stages of most species of meroplankton are attracted to and are concentrated in the intake canal. Such a phenomenon when accompanied by the increased intake (capacity) is indicative of an intake design which does not reflect best technology available to minimize adverse environmental impact.

6.3.3.3.2.3 Fine-Mesh Screening Studies

Because of the EPA's concern for the potential loss of organisms by entrainment in the Unit 4 once-through condenser cooling system, the Applicant undertook to evaluate various techniques for excluding entrainable organisms. A review of available intake techniques was conducted to evaluate the engineering reliability and appropriateness to the Big Bend site as well as the biological effectiveness. These evaluations indicated that fine-mesh screening had the greatest potential for effective application at Big Bend. Accordingly, in preliminary studies conducted during the summer of 1979, a partial fine-mesh screen was added to an existing traveling screen at Big Bend Unit 1; also included was a flume study in which various test organisms were impinged on a fine-mesh screen panel over a range of impingement velocities and durations. A detailed description of the facilities and methods employed and the results of the study have been presented by Tampa Electric Company (1980c). In summary, the survival rates observed in both test facilities were sufficient to warrant proceeding with additional investigations during 1980, using a prototype traveling screen equipped with a full-scale fine-mesh screen, including all features required for an in-service installation. A biological investigation with this prototype system was conducted from March to August 1980. A detailed description of the test facility, methods employed, and results of the prototype study are presented in another report (Tampa Electric Company 1980d). A summary of the study is provided below.

The prototype test screen was situated on a platform located in the intake canal of the Big Bend Power Station (Figures 6-47 through 6-50). The prototype screen was a dual-flow type and incorporated all of the features required for fine screening. Seals were incorporated between screen baskets and between the baskets and the side frame to minimize the passage of organisms through these areas. The screening medium was 0.5-millimeter mesh made of woven-monofilament polyester, and the 42 screen baskets were 2 feet wide and 2 feet high. The screen could be operated at speeds of up to 28 fpm; three speeds of 7, 14, and 28 fpm were selected for study. These speeds corresponded to maximum impingement durations of approximately 7, 4, and 2 minutes, respectively. Waterflow through the screen was supplied by an in-line pump (an adapted ship-bow thruster pump) located under the test platform and connected directly to the screen via a transition section.

Assorted pulleys allowed for flow adjustments. During the study, pulleys were selected to achieve approach velocities of 0.5 and 1.0 fps. The preliminary flume studies indicated that these impingement duration times and screen approach velocities were optimal for the survival of organisms.

The test screen incorporated shallow lifting buckets on each 2-foot-wide screen basket, which retained approximately 1 inch of water. A low-pressure (10-psi) spray header on the ascending side of the screen removed organisms from the screen-mesh surface and lifting buckets. A high-pressure (55-psi) spray header on the descending side of the screen removed any remaining debris into a separate trough. A screen-wash pump with a strainer was located on the operating deck, which took suction from the filtered water (bow-thruster pump discharge). As each screen basket passed the spray wash, organisms on the mesh or in the lifting bucket were gently rinsed into a collection trough. Once in the trough, the organisms flowed by gravity into a primary collection tank, from which they were drained into a secondary collection chamber. This collection chamber also served as the container in which the organisms were transported to the laboratory for initial and latent (up to 96-hour) mortality determinations.

In order to determine the survival of organisms after impingement on, and removal from, the prototype screen, screen samples were collected routinely throughout the study program. Tests were conducted with all combinations of screen travel speeds of 7, 14, and 28 fpm and approach velocities of 0.5 and 1.0 fps. The procedures used in all tests were as follows: before sampling, the bow-thruster pump and screen were set at the desired operating point for the specific test being conducted. The low-pressure spray wash was preset at 10 psi and was then shut off until the sample was taken. Once the screen was in full operation and the movement of water and organisms through the test facility was in a steady state, sampling was initiated by turning on the low-pressure spray, allowing the contents of a predetermined number of screen baskets to be rinsed into the collection trough, and then shutting off the spray. The number of baskets washed differed for each water-velocity and screen-travel-speed condition, so that at each condition the total volumes of water sampled by the prototype screen were equivalent. The organisms washed into the collection trough were carried into a primary collection area that contained a screened overflow (0.25-millimeter mesh). In this area, large debris (leaves, shells, ctenophores) could be removed as the area drained. Once the water level reached the bottom of the overflow screen, the sample was concentrated to the point where it could be drawn down into the secondary collection and transport chamber, where the sample was further concentrated. The drawdown was slow and gentle to avoid stress from high velocities and turbulence in the drain line and container. Once the sample had been completely transferred, the container was sealed and transported to the land-based laboratory for studies of initial and latent effects.

In addition to screen-wash samples, control organisms were collected and held for comparison with the latent mortality values experienced among organisms collected by the screen. Control organisms were collected from the intake canal by suspending a stationary plankton net in the canal flow (velocity $\leq$ 0.4 fps) for approximately 5 minutes. The net was then gently washed and the contents were transported to the laboratory, where the sample was sorted for the life stages of a select group of meroplankton organisms. Individuals of each life stage were then held for 96 hours.

During the study, emphasis was placed on obtaining survival data for life stages of a select group of RIS (Table 5-55). However, while species identification was generally possible in the screen-wash survival studies because of careful handling techniques, in most cases individual species did not occur frequently enough to permit a meaningful analysis of the data at the species level. Therefore, it was generally necessary to combine species into higher taxonomic groupings. For example, the three sciaenid RIS (black drum, silver perch, and spotted seatrout) were often combined into the grouping "sciaenids." As such, the data analyses were designed to include with these RIS all other sciaenids that occurred in each sample.

On the other hand, in some cases an RIS life stage always occurred in such abundance that it could always be analyzed at the species level. The eggs of the bay anchovy are the most notable example of such a life stage. Several RIS were never observed in screen-wash samples: pink shrimp, American oyster, and blue crab.

Tables 6-52 through 6-55 present viability data for the various larval stages of the fish and macroinvertebrate taxa impinged on the prototype fine-mesh screening system at Big Bend during the study period from March to August 1980. Included are data on the rates of initial survival, hatchability (of fish eggs), and latent survival after 48 and 96 hours under controlled laboratory conditions. Also included in the tables are viability data on the larval stages of these taxa, which were collected as control organisms for estimating the rates of mortality due not to screen impingement but to natural effects and the effects of handling and holding in the laboratory.

The viability of the larval organisms after impingement on the prototype fine-mesh screening system was found to vary with taxon and life stage. Of the taxonomic categories studied, initial survival rates were highest for the larvae of decapod crustaceans; on the average, more than 90 percent of these taxa survived. Fish larvae, as a group, suffered the highest initial mortalities after impingement; in most cases, survival rates averaged less than 20 percent. The mean initial survival rates for fish eggs ranged from 3 to 100 percent, depending on the taxon. Since egg-development time is generally less than the 96-hour holding period, the proportion of impinged fish eggs that hatched during the latent-mortality studies is a measure of the viability of these eggs. The mean hatchability for the study period ranged from 80 to 100 percent, depending on the taxon.

The proportion of organisms that were alive after being held in the laboratory for 48 and 96 hours was used as a measure of the latent effects of screen impingement. However, the investigators suggested that the high mortality of many of the meroplankton organisms held from 48 to 96 hours under controlled conditions may limit the usefulness of the 96-hour survival rates. As with the initial determinations, the latent-mortality rates of organisms impinged by the prototype screening system were also taxon- and life-stage-specific, as was the relationship between the rates of survival at 48 and 96 hours.

Viability data for control organisms were, in many cases, limited by the small number of observations. However, these data indicate that natural mortality and mortality due to laboratory-handling stresses are contributing factors in the mortalities observed among organisms impinged on the fine-mesh screens. Therefore, the estimates of test mortality presented in Tables 6-52 through 6-55 should be considered as the cumulative effects of impingement, laboratory-handling stresses, and natural mortality.

Statistical analyses were conducted to evaluate the effects of ambient water temperature, screen speed, and approach velocity on the viability of impinged organisms. The results of these analyses are presented in Tables 6-56 and 6-57. The analyses indicate that these variables explain relatively little (R^2 values ranged from 0.01 to 0.56) of the variability in survival rates of the meroplankton taxa studied. However, the variables that were most often statistically significant ($p \leq 0.05$) were water temperature and approach velocity. Latent mortality rates after 96 hours were highest for organisms impinged on the screens during the period of highest ambient water temperature (June-August). The data also indicated that the influence of water temperature was more apparent after 96 hours than after 48 hours. Mortality was greater at an approach velocity of 1.0 fps than at 0.5 fps. The investigators emphasized that, while both water temperature and approach velocity were, in several cases, significantly related to the mortality rates of organisms impinged on the fine-mesh screens, these variables explained relatively little of the variability in the rates.

6.3.3.3.2.4 Supplemental Studies

Spray-Wash Efficiency Study

Since the spray-wash system incorporated into the prototype screen represents a new design, the efficiency of the system in washing organisms into the collection trough was investigated. It was not expected that the system would be totally effective in removing organisms; however, it was expected that quantitative and qualitative data would identify potential design changes that would optimize system efficiency.

Samples were collected in a screened collection box as the water exited the debris trough on the high-pressure spray-wash side of the screen while the low-pressure spray wash was in operation (Figure 6-50). In this way, the number of organisms removed by the low-pressure spray could be directly compared to the number carried over to the high-pressure spray, and the efficiency of the low-pressure spray wash could be calculated. It was expected that the speed of the screen would influence cleaning efficiency, with efficiency expected to decrease as speed increased. Therefore, samples were taken at all three travel speeds (7, 14, and 28 fpm). Samples were also taken at both screen-approach velocities of 0.5 and 1.0 fps.

Each sample was collected by washing down the screened collection box and was then preserved for later analysis. Laboratory analysis consisted of enumeration, identification to lowest feasible taxonomic level, the determination of life stage, and size measurements (fish larvae only). Screen-efficiency samples could then be compared to a standard screen-wash sample taken at nearly the same time.

In order to conduct the data analysis, it was necessary to combine identified taxa into groups because, in most cases, a single species, genus, or even family did not occur frequently enough to permit a meaningful analysis. The taxonomic level of each group was determined as the lowest level that would allow the inclusion of all important taxa from both the spray-wash efficiency samples and the comparable screen-wash samples.

To determine the spray-wash efficiency for each taxonomic group, the numbers of organisms in the spray-wash and screen-wash samples were converted to numbers per cubic meter of water passing through the fine-mesh screen. Then, the percentage of organisms not removed by the low-pressure spray-wash system was calculated.

A total of 15 spray-wash-efficiency tests were conducted during the study program: 10 tests in April, 3 tests in June, and 2 tests in July. A listing of the taxa recovered and identified is given in Table 6-58. Anchoa mitchilli (eggs and larvae) was the only species that occurred frequently enough to be analyzed at the species level. All other species occurred in relatively low abundance in both screen-wash and spray-wash samples. Accordingly, these species were combined into larger taxonomic groupings.

The results of spray-wash efficiency testing are given in Table 6-59. Eggs showed the highest degree of carryover (i.e., were not removed from the mesh and lifting bucket by the low-pressure spray). Larvae were removed more effectively, but still showed a relatively high rate of carryover. Decapod zoeae were removed most efficiently.

The data were analyzed to determine whether screen speed (7, 14, and 28 fpm) or approach velocity to the screen (0.5 and 1.0 fps) influenced spray-wash efficiency. While it was expected that increased screen speed would decrease efficiency, this relationship was not detected for any of the taxa studied. Approach velocity appeared to influence Anchoa mitchilli and Perciformes egg carryover; fewer eggs were carried over at 1.0 fps than at 0.5 fps.

It was suggested that the power of the analysis may have been limited by the high degree of variability in the data (Table 6-59) and, with the exception of A. mitchilli, the generally low abundance of organisms tested.

Prototype Screening Efficiency

In order to determine the efficiency of the prototype screen in preventing the passage of organisms, whether through the 0.5-millimeter mesh or the various sealed areas in the screen assembly, samples of organisms present in the screened water were collected. Samples were preserved and processed in the laboratory. Laboratory analysis consisted of enumeration, identification to the lowest feasible taxonomic level, the determination of life stage, and size measurements (fish larvae only).

Samples were collected with a sampling pump (Figure 6-50) that discharged into two conical plankton nets submerged in tanks. The pump was run for at least 1 hour to obtain sample volumes no smaller than 100 cubic meters.

The analysis of screening efficiency was limited by a lack of data. A total of 10 tests were conducted; however, only the results of four (two at a screen speed of 7 fpm and two at 14 fpm) were analyzed. A listing of the recovered and identified taxa is given in Table 6-60. Anchoa mitchilli (eggs and larvae) was the only species that occurred frequently enough to be analyzed at the species level. All other species occurred in relatively low abundance in both screen-wash and screen-efficiency samples. Therefore, most of the remaining species were combined into larger taxonomic groupings. The mean percentage loss data are presented in Table 6-61 for each species or group that occurred in enough abundance for analysis. The available data indicated that a portion of the organisms were not completely screened. These loss data do not point out the causal agent. However, the investigators indicated that an analysis of the length of the larvae collected in the screen-wash and screen-efficiency samples suggested that organisms had passed between the seals.

Plankton Net Sampling

Plankton net samples were collected adjacent to the prototype screen structure using the techniques employed in the 1979 Aquatic Ecology Study (Phillips and Blanchet 1980a,b). Four replicate samples were collected on 1 day during each week of screen sampling at the same time that screen samples were collected. Samples were preserved for later processing. Laboratory analysis for RIS consisted of enumeration, identification to species or the lowest feasible taxonomic level, the determination of life stage, and size measurement (fish larvae only).

Species collected in plankton nets were compared with species collected in the screen-wash samples. With the exception of yolk-sac larvae of *Cynoscion nebulosus* and *Pogonias cromis* (which were found only in net samples in low abundance and only on one date), all species and life stages collected in the net were also recorded from the screen-wash samples.

The results indicated that, qualitatively, the prototype screen sampled nearly all species and life stages that were collected in plankton net samples from the plant intake canal.

Investigations of the Organism-Return System

An essential element of the fine-mesh screening concept is the system that returns the impinged meroplankton to Tampa Bay. The Applicant selected a trough design as the conveyance mechanism for the return of organisms to the Bay.

Flume Study. In order to evaluate the biological effects of travel through a return trough, survival studies were conducted with test animals placed in a circular flume. The flume was 12 inches deep and 9 inches wide, and had an outer diameter of 8.3 feet. Water contained in the flume was circulated at 2 fps by water-drive paddles.

Tests were conducted by placing individual groups of RIS life stages into the flume and allowing them to circulate at velocities of 2 fps for 1 hour, which is equivalent to traveling a straight distance of 7,200 feet. This velocity was considered by the Applicant to be sufficiently high to move organisms rapidly to a release site, but low enough to minimize damage from turbulence and abrasion. Test organisms were obtained from the prototype screen and, therefore, at the end of flume testing had experienced the entire process of impingement, removal, and transport.

Control organisms collected from the prototype screen were subjected to the same conditions, except that the water in the flume was not circulated. These organisms were collected after 1 hour to determine whether the flume-testing procedure contributed to any observed mortality.

After each test run, the organisms were removed from the flume by draining the water into a screened collection box. The organisms were then enumerated as live, stunned, or dead, and live individuals were held for 96 hours to determine latent mortality. Holding procedures were identical with those used in the prototype-screen evaluation.

Organism Survival Studies. In conjunction with flume studies, a study of organism survival in water from the proposed organism-return canal (ORC) was conducted during 1 week each month from June through August 1980. Organisms collected with a plankton net were sorted into batches of 30 (lots of 5) and held in the ORC water for 96 hours. In addition, control organisms collected with the net were held in the plant-intake-canal (PIC) water for a comparison of latent survival.

Although data for the flume and organism survival studies were collected independently, the statistical analysis combined all the data together. This was done to control for the large day-to-day variability in survival that often occurred. As discussed above, 96-hour control and test mortality was very high during the phase of testing when most of the flume and organism survival studies were conducted. Therefore, the investigators believed that it would have been of little value to analyze the 96-hour results. Accordingly, the analyses focused on 48-hour data, with 48-hour survival as the primary variable of interest. This variable is the percentage of organisms that survived flume tests, control tests, or PIC and ORC tests for 48 hours. The variable is actually the product of initial survival and 48-hour holding survival.

A total of 15 flume tests and 8 control tests were conducted. In addition, eight net samples of organisms to be held in the ORC and PIC water were taken on corresponding sampling dates. The 8 dates on which this sampling took place spanned the period from mid-June to mid-August 1980. Before this, a total of 18 samples of net-collected organisms had been held in ORC or PIC water. This earlier testing period occurred from late May to early June 1980.

Anchoa mitchilli and Harengula jaguana were the only species collected in sufficient abundance to be analyzed separately. Both of these species are RIS. All other species occurred in relatively low abundance. For this reason, most of the remaining species were combined into larger taxonomic groupings for analysis. A listing of the taxa and groupings used in this study is given in Table 6-62.

For the flume studies, the results represent the combined data of all the life stages. The results were combined because organisms that were placed in the flume as eggs often hatched before or during testing, and therefore the life stage at which testing had occurred could not be precisely determined. This occurred for all fish species but more frequently with organisms of the Perciformes group.

The analyses for Anchoa mitchilli, Harengula jaguana, and Perciformes flume tests (June through August) indicated that there was no significant difference between flume-test and control survival to 48 hours. Similarly, no significant differences were observed in 48-hour survival of organisms held in PIC and ORC water during either study period. Data on mean 48-hour total survival for these two species and the Perciformes group are presented in Table 6-63. These rates of survival represent the mean for flume and PIC/ORC survival tests that were conducted concurrently and therefore do not include data from the earlier (May 22 to June 3) sampling period.

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The analyses for shrimp and crab zoeae included only the flume-test and control data (Table 6-63). These data indicated that there was no significant difference in flume-test and control survival for 48 hours.

There was enough data from the earlier (May 22 to June 3) sampling period to permit an analysis of crab zoeae held in ORC and PIC water, but shrimp zoeae were not abundant enough to permit analysis. These results indicated that there was no significant difference in 48-hour survival of crabs held in ORC and PIC water; the mean survival was 88 percent.

Evaluation of the Proposed Organism-Return Canal. Two potential sites were considered by the Applicant for returning the organisms removed from the proposed fine-mesh screening systems (Figure 6-51). The preferred site (Area 1) is a large, dead-end, undeveloped canal located approximately 300 meters (1,000 feet) north of the plant intake canal. The other potential site (Area 2) is off the breakwater to the south of Fish Hook Key. Of the two, Area 1 is much closer to the plant and therefore would allow for a faster return of the organisms with less potential for transport stresses. Because of flushing rates, it was thought that the ORC could differ in water quality from the PIC to the extent that organism survival would be affected. In order to identify any important differences in water quality between the ORC and the PIC, water quality and hydrographic and biological studies of each canal were made from May through September 1980.

Area 2 was considered an area of ambient bay conditions and acceptable water quality, should it be used. Therefore, biological and water quality data were not gathered for this location.

As shown in Figure 6-52, sampling stations were established in the PIC and the ORC. A complete discussion of sampling procedures and the data obtained are presented in another report (Tampa Electric Company 1980d).

The major conclusions made from the data collected during the study were as follows:

1. Hydrographic parameters (temperature, salinity, dissolved oxygen, and pH) were generally similar at the PIC and the ORC. Recurrent anoxic conditions were not present in either canal.

2. Values of water quality parameters (micronutrients, pesticides, and metals), chlorophyll a, and fecal coliform levels were generally low and similar in the two canals.

3. Phytoplankton, zooplankton, and meroplankton communities were generally similar in species composition and density in the two canals.

4. Overall, the major biological and water quality parameters of the two canals were similar, with small-scale variations occurring that were attributed to natural spatial patchiness in the estuarine environment.

Reentrainment Evaluation. The two candidate release areas were assessed for the potential for reentraining organisms released from a return trough. In the assessment, hydrodynamic models were used to simulate the movement of released organisms with relation to the intake flow. Because of the physical characteristics of the two areas, different hydrodynamic models were used for each area. Detailed descriptions of these models and associated assumptions are presented elsewhere (Tampa Electric Company 1980d).

The bathymetry of the ORC is shown in Figure 6-53. Organisms released into the canal would be expected to disperse along its length and, in time, would leave the canal as a result of tidal flushing and the inflow of screen-wash water. It was assumed that, once planktonic organisms left the canal, they would enter the intake flow and would be reentrained.

The strategy for the analysis was to introduce organisms into the ORC and simulate the rate at which they disperse out of the canal and become susceptible to reentrainment. A long retention time within the canal would allow organisms to grow and develop beyond the point where they would be susceptible to reentrainment in the intake structure. Susceptibility to entrainment is highly dependent on swimming ability and the behavioral response of organisms, both of which are functions of size and life stage.

The simulation of the organism flushing rate in the ORC used two release locations: one approximately 2,540 feet and another approximately 3,900 feet from the mouth of the approximately 4,000-foot-long canal. The analysis of two release locations in the canal permitted an evaluation of the effect of the release location on reentrainment rate. The results of these simulations are presented in Figure 6-54. The loss rate of organisms is dependent on the release location. The highest retention occurred with the release point located at the eastern end of the canal. With release at this location, more than 90 percent of the organisms would remain in the canal after 15 days and approximately 60 percent would remain after 30 days. If released at a point approximately 2,540 feet from the canal mouth, approximately 75 percent of the organisms would remain after 15 days and approximately 45 percent would remain after 30 days.

Given the reported rapid growth rates of fish and crustaceans while in the planktonic stage, the investigators suggested that most released organisms would develop beyond an entrainable size and life stage before leaving the canal. In addition, most invertebrate larvae and young of many fish species were expected to become demersal within the ORC. While some of these and other released organisms would reside in the vicinity of the station, as the organisms grew and developed, movement into the portions of Tampa Bay would occur. Because of the long retention time in the ORC and the other factors mentioned, it was predicted that few organisms released near the east end of the canal would be subject to reentrainment.

The alternative release location at Fish Hook Key was evaluated by simulating the dispersion of organisms from the midpoint of the breakwater within the nearby region of Tampa Bay. At a point just north of Fish Hook Key, organisms were considered reentrainable in the intake flow. Assuming a constant release rate of organisms, the density of organisms at the point of reentrainment was calculated and the intake flow rate was used to determine the rate of reentrainment. While the results did not quantify the reentrainment rate, the investigators believed the analysis demonstrated that the reentrainment rate would be high and therefore this location would be less desirable as a release location for screened organisms.

The results of the evaluation suggested that few organisms returned to the east end of the ORC would be subject to reentrainment. The Applicant therefore selected the ORC as the preferred release location.

after reviewing the fine-mesh screening studies, the U.S. Environmental Protection Agency (1981b) developed a Tentative Finding and Determination, the conclusions of which are as follows:

1. The prototype device appeared to be approximately 56 percent effective in screening eggs and larvae from source water. Suggested changes in the design of the spraywash system, lifting buckets and seals are proposed as means to substantially improve the screening efficiency of the intake device.

2. Fish eggs and invertebrate larvae collected from the fine-mesh screen exhibited a low level of mortality. Many of the taxa involved were species of sport and commercial value, i.e., stone crab and drum.

3. Fish larvae collected from the fine-mesh screens or by plankton nets for control tests exhibited a high degree of mortality. The observed mortality, however, cannot be concluded to be solely due to impingement effects of the fine-mesh screen. Testing procedures, i.e., sampling and hauling, can be viewed as factors contributing to the apparent low survival of the larval organisms. The immediate return of animals upon collection from the screening device may enhance the survival of fish larvae.

4. The proposed transport systemof animals to the dead-end waterway north of the plant appears to be an acceptable organism return system. Additional testing is necessary to verify the dispersion of returned organisms to Hillsborough Bay.

5. Based on the results of the Fine-Mesh Screening Prototype Studies, sufficient information was provided to determine that the fine-mesh screening of intake structures is a viable technology that will minimize entrainment effects. Furthermore, the installation of fine-mesh screens on Big Bend Units 3 and 4 will provide for entrainment effects approximately equal to the current impacts associated with the operation of Units 1, 2 and 3 with conventional intake technology. The design modification effected by the addition of fine-mesh screens at the cooling water intake for Units 3 and 4 minimizes adverse environmental impact for the purpose of Section 316(b) of the Act.

6.3.4 PEOPLE

The proposed Big Bend Unit 4 is scheduled to begin operations in 1985. This section discusses the socioeconomic impacts associated with the operation of that unit.

6.3.4.1 Employment

The operation of Unit 4 is expected to create 50 permanent jobs. It is expected that the Tampa labor market will supply most of the skills necessary to operate the plant, and that, wherever possible, TECO will hire workers from the local market (Tampa Electric Company 1979). Although no estimate of the number of operating and maintenance personnel to be hired locally has been provided, it may be reasonably assumed

Table 6-20. Tolerance of selected species to continuously chlorinated effluent[a]

Species	Life form	96-hour LC_{50} (mg/ℓ)	Reference
Crassostrea virginica (Ostreidae) Eastern oyster	Juvenile	0.023	Roberts et al. (1975)
	Juvenile	>1.500	Bongers et al. (1977)
Callinectes sapidus (Portunidae) Blue crab		0.1	Mattice and Zittel (1976)
Brevoortia tyrannus (Clupeidae) Atlantic menhaden	Juvenile	$0.09 < LC_{50} < 0.223$	Bongers et al. (1977)
Leiostomus xanthurus (Sciaenidae) Spot	Juvenile	$0.09 < LC_{50} < 0.223$	Bongers et al. (1977)
Menidia menidia (Atherinidae) Atlantic silverside	Larvae/ juvenile	0.037	Roberts et al. (1975)

Abbreviations:
LC_{50} = concentration lethal to 50 percent of the test organisms after 96 hours.
mg/ℓ = milligrams per liter.

[a]Adapted from Tampa Electric Company (1981c).

Table 6-21. Flow, velocity, and temperature characteristics of the condenser-cooling-water systems for Big Bend Units 1-4

Parameter	Unit 1	Unit 2	Unit 3	Unit 4
Intake channel				
Unit flow, cfs	537	537	537	537
Cumulative flow, cfs	2,148	1,611	1,074	537
Velocity, fps	0.56	0.42	0.28	0.14
Discharge channel				
Maximum temperature rise, °F	16.8	16.8	16.8	16.8
Avgerage temperature rise, °F	11.0	11.0	11.0	11.0

Abbreviations:
cfs = cubic feet per second.
fps = feet per second.

Table 6-32. Data on water quality of effluents produced at four different bottom-ash disposal areas[a,b]

Component	Effluents[d] A	B	C	D	Avg. A+B+C+D	EPA standard[e]	FDER[c] ground-water quality standard
Iron, total	0.90	0.91	0.98	0.71	0.88		
Iron, dissolved	0.03	0.06	0.05	0.03	0.043		
Nickel	0.009	0.02	0.03	0.02	0.02		
Copper	(f)	0.008	0.03	0.004	0.014		
Cadmium	0.001	(f)	(f)	(f)	0.001	0.01	0.01
Chromium	(f)	(f)	(f)	0.006	0.006	0.05	0.05
Lead	(f)	(f)	(f)	(f)		0.05	0.05
Mercury	(f)	(f)	(f)	(f)		0.002	0.002
Selenium	(f)	(f)	(f)	(f)		0.01	0.01
Zinc	0.007	0.13	0.03	0.01	0.044		
Manganese	0.10	0.29	0.15	0.01	0.138		
Arsenic	(f)	(f)	(f)	0.01	0.01	0.05	0.05
Antimony	(f)	(f)	(f)	(f)			
Beryllium	(f)	(f)	(f)	(f)			
Silver	(f)	(f)	(f)	(f)		0.05	
Titanium	(f)	(f)	(f)	(f)			
Total dissolved solids							
Total suspended solids		4.6	7.7	55.6			
pH	7.8	6.8	7.8	8.4			

Abbreviations:
EPA = U.S. Environmental Protection Agency.
FDER = Florida Department of Environmental Regulation.

[a]From Tampa Electric Company (1981c).
[b]Values are in milligrams per liter and were obtained from Utility Water Act Group (1979).
[c]Florida Administrative Code, Chapter 17-3.101.
[d]The following letters identify the coal type for each pond from which the samples were taken:
A. Western West Virginia coal
B. Eastern Ohio coal
C. Southern Ohio coal
D. Southern Illinois coal
These effluents were used to provide conservative estimates of leachate quality.
[e]National interim primary drinking water standards.
[f]Values less than the minimum quantifiable concentration from Utility Water Act Group (1979).

Table 6-33. Numbers of fish and macroinvertebrates impinged in 24 hours on the traveling screens of the condenser cooling system at one generating unit of Big Bend Station, January 1976 to March 1977[a,b]

Taxon	1976 January-March (6/91)[c] Total number collected during impingement sampling	1976 January-March (6/91)[c] Impingement rate per day[d]	1976 April-June (7/91)[c] Total number collected during impingement sampling	1976 April-June (7/91)[c] Impingement rate per day[d]	1976 July-September (6/92)[c] Total number collected during impingement sampling	1976 July-September (6/92)[c] Impingement rate per day[d]	1976 October-December (7/92)[c] Total number collected during impingement sampling	1976 October-December (7/92)[c] Impingement rate per day[d]	1977 January-March (5/90)[c] Total number collected during impingement sampling	1977 January-March (5/90)[c] Impingement rate per day[d]
Total fishes	328	54.7	1,362	194.6	2,704	450.7	1,404	200.6	3,996	793.2
Anchoa mitchilli										
Bay anchovy	35	5.8	64	9.1	33	5.5	733	104.7	2,956	591.2
Bairdiella chrysoura										
Silver perch	29	4.8	576	82.3	2,093	348.8	149	21.3	250	50.0
Lagodon rhomboides										
Pinfish	24	4.0	181	25.9	91	15.2	19	2.7	191	38.2
Cynoscion arenarius										
Sand seatrout	16	2.7	202	28.9	57	9.5	83	11.9	53	10.6
Prionotus scitulus										
Leopard searobin	25	4.2	62	8.9	13	2.2	61	8.7	140	28.0
Chloroscombrus chrysurus										
Atlantic bumper	3	0.5	3	0.4	79	13.2	168	24.0	49	9.8
Other fishes	196	32.7	274	39.1	338	56.3	191	27.3	327	65.4
Total macroinvertebrates	2,458	409.7	1,073	153.3	2,612	435.3	1,244	177.7	2,314	462.8
Penaeus duorarum										
Pink shrimp	944	157.3	382	54.6	1,923	320.5	246	35.1	289	57.8
Callinectes sapidus										
Blue crab	495	82.5	20	2.9	3	0.5	119	17.0	619	123.8
Limulus polyphemus										
Horseshoe crab	549	91.5	104	14.9	94	15.7	104	14.9	371	74.2
Portunus gibbesi	145	24.2	66	9.4	54	9.0	267	38.1	346	69.2
Lolliguncula brevis										
Brief squid	76	12.7	197	28.1	318	53.0	82	11.7	53	10.6
Squilla empusa	77	12.8	21	3.0	0	0	157	22.4	311	62.2
Other macroinvertebrates	172	28.7	283	40.4	220	36.7	269	38.4	325	65.0

[a]Adapted from Peekstok, Page, and Haynes (1977).
[b]Sampling conducted at intervals of approximately 2 weeks at Unit 1 or 2.
[c]Numbers in parentheses are the ratio of sampling days to the total number of days in the 3-month period.
[d]Total number collected during impingement sampling divided by the number of impingement sampling days.

Table 6-34. Estimates of the number of fish and macroinvertebrates impinged on the traveling screens of the condenser cooling systems during the continuous operation of Big Bend Units 1, 2, and 3 from January 1976 to March 1977[a,b]

Taxon	1976				1977	Annual	
	January-March (89.7)[c]	April-June (156.5)[c]	July-September (236.1)[c]	October-December (241.7)[c]	January-March (212.6)[c]	January-December 1976 (724.0)[c]	April 1976-March 1977 (846.9)[c]
Total fishes	4,906	30,455	106,428	48,489	168,650	190,278	354,022
Anchoa mitchilli Bay anchovy	520	1,424	1,299	25,308	125,701	28,551	153,732
Bairdiella chrysoura Silver perch	431	12,880	82,366	5,149	10,631	100,826	111,026
Lagodon rhomboides Pinfish	359	4,053	3,589	653	8,122	8,654	16,417
Cynoscion arenarius Sand seatrout	242	4,523	2,243	2,876	2,254	9,884	11,896
Prionotus scitulus Leopard searobin	377	1,393	520	2,103	5,953	4,393	9,969
Chloroscombrus chrysurus Atlantic bumper	45	63	3,117	5,801	2,084	9,026	11,065
Other fishes	2,932	6,119	13,294	6,599	13,905	28,944	39,917
Total macroinvertebrates	36,746	23,991	102,792	42,954	98,401	206,483	268,138
Penaeus duorarum Pink shrimp	14,108	8,545	75,683	8,484	12,289	106,820	105,001
Callinectes sapidus Blue crab	7,399	454	118	4,109	26,322	12,080	31,003
Limulus polyphemus Horseshoe crab	8,207	2,332	3,707	3,602	15,776	17,848	25,417
Portunus gibbesi	2,170	1,471	2,125	9,210	14,713	14,976	27,519
Lolliguncula brevis Brief squid	1,139	4,398	12,515	2,828	2,254	20,880	21,995
Squilla empusa	1,148	470	0	5,415	13,225	7,033	19,110
Other macroinvertebrates	2,575	6,321	8,644	9,306	13,822	26,846	38,093

[a]Adapted from Peekstok, Page, and Haynes (1977).
[b]Estimates calculated by multiplying daily impingement rates by the number of days within the quarterly or annual period and by the total number of generating units (three) operating at the plant site during 1976-1977.
[c]Total number of unit-days that Units 1, 2, and/or 3 were in operation.

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Table 6-35. List of all representative important species collected from the traveling screens at Big Bend Station between March 14, 1979, and February 12, 1980 (Sheet 1 of 2)

Species	Station																							
	March 14, 1979				March 27, 1979				April 10, 1979				April 24, 1979				May 10, 1979				May 25, 1979			
	12	18	24	6	12	18	24	6	12	18	24	6	12	18	24	6	12	18	24	6	12	18	24	6
Penaeus duorarum	2	--	1	2	5	3	9	8	--	--	7	10	--	1	18	12	4	--	2	6	1	--	--	2
Callinectes sapidus	2	3	3	6	2	1	3	1	--	--	2	2	1	--	--	1	--	1	1	2	--	--	--	1
Menippe mercenaria	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--
Harengula jaguana	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anchoa mitchilli	--	1	1	2	1	1	10	5	--	1	--	--	--	--	--	--	--	2	1	--	--	--	--	--
Bairdiella chrysoura	--	--	1	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	1	20	6	38	43
Cynoscion nebulosus	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pogonias cromis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	4	5	6	11	9	6	23	15	--	1	9	12	1	1	18	13	4	3	5	9	21	6	38	46
	June 19, 1979				July 3, 1979				July 17, 1979				July 31, 1979				August 14, 1979				August 28, 1979			
Penaeus duorarum	--	--	--	2	--	--	51	56	14	2	30	11	77	15	57	40	39	5	74	29	57	3	73	36
Callinectes sapidus	1	1	--	1	1	--	2	5	1	--	2	--	--	--	--	--	--	--	--	--	--	--	--	1
Menippe mercenaria	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Harengula jaguana	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anchoa mitchilli	2	3	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--
Bairdiella chrysoura	18	4	81	19	4	--	46	16	2	1	2	1	--	1	--	1	5	1	3	4	1	1	1	4
Cynoscion nebulosus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pogonias cromis	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	21	8	83	22	5	1	99	78	17	3	34	12	77	16	57	41	44	7	77	33	58	4	74	41

Note: See note at end of table.

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Table 6-35. List of all representative important species collected from the traveling screens at Big Bend Station between March 14, 1979, and February 12, 1980 (Sheet 2 of 2)

Species	Station																							
	12	18	24	6	12	18	24	6	12	18	24	6	12	18	24	6	12	18	24	6	12	18	24	6
	September 11, 1979				September 25, 1979				October 9, 1979				October 23, 1979				November 9, 1979				November 20, 1979			
<u>Penaeus duorarum</u>	34	4	242	64	19	5	62	41	86	11	67	45	12	--	13	21	4	8	--	30	15	9	44	40
<u>Callinectes sapidus</u>	--	--	1	2	--	--	1	--	--	--	--	--	--	--	--	1	--	--	--	--	2	--	1	--
<u>Menippe mercenaria</u>	--	--	1	--	--	--	1	--	--	--	--	--	--	--	--	2	1	--	1	--	1	--	--	--
<u>Harengula jaguana</u>	1	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<u>Anchoa mitchilli</u>	--	1	2	--	--	1	1	--	2	--	8	1	2	--	4	4	--	--	--	--	--	5	9	--
<u>Bairdiella chrysoura</u>	3	5	5	8	--	--	3	4	5	--	--	4	1	--	1	2	--	--	1	--	1	--	3	2
<u>Cynoscion nebulosus</u>	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<u>Pogonias cromis</u>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	38	11	251	74	19	6	68	45	95	11	75	50	15	--	16	30	5	8	2	30	19	14	57	42
	December 6, 1979				December 18, 1979				January 1, 1980				January 15, 1980				January 29, 1980				February 12, 1980			
<u>Penaeus duorarum</u>	18	7	11	14	2	1	9	3	1	2	9	4	--	2	--	1	2	2	2	1	4	1	--	2
<u>Callinectes sapidus</u>	4	1	3	8	1	--	2	2	2	3	6	23	--	--	7	6	9	1	7	19	27	8	28	24
<u>Menippe mercenaria</u>	--	--	--	--	2	--	2	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
<u>Harengula jaguana</u>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<u>Anchoa mitchilli</u>	33	9	19	11	1	--	3	2	4	3	6	9	--	--	--	--	--	1	--	1	2	--	2	2
<u>Bairdiella chrysoura</u>	8	4	15	8	--	2	12	1	--	2	2	--	--	--	1	--	--	--	--	--	1	--	--	--
<u>Cynoscion nebulosus</u>	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<u>Pogonias cromis</u>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	63	22	48	41	6	3	28	8	7	10	24	36	--	2	8	7	11	4	9	21	34	9	30	28

Note: The total for the sampling period covered before is 2,570. The totals for each species are as follows: <u>P. duorarum</u>, 1,738; <u>C. sapidus</u>, 199; <u>M. mercenaria</u>, 14; <u>H. jaguana</u>, 4; <u>A. mitchilli</u>, 181; <u>B. chrysoura</u>, 431; <u>Cynoscion nebulosus</u>, 4; <u>Pogonias cromis</u>, 1.

Table 6-36. Projections of the number of RIS fish and macroinvertebrate taxa impinged annually on the cooling-water traveling screens of Big Bend Units 1-3 and Units 1-4[a]

Taxon	Projected annual impingement for Units 1-3[b]	Projected annual impingement for Units 1-4[c]
	Macroinvertebrates	
Penaeus duorarum Pink shrimp	73,500	98,360
Callinectes sapidus Blue crab	12,750	17,064
Menippe mercenaria Stone crab	600	786
	Fishes	
Anchoa mitchilli Bay anchovy	8,250	10,630
Harengula jaguana Scaled sardine	165	220
Menidia beryllina Tidewater silverside	NI	NI
Bairdiella chrysoura Silver perch	21,750	29,444
Cynoscion nebulosus Spotted seatrout	213	284
Pogonias cromis Black drum	42	56

Abbreviations: RIS = representative important species.
NI = no information; not collected during 1979-1980 impingement studies.

[a]Projections based on impingement collections made at intervals of approximately 2 weeks from March 14, 1979, to February 12, 1980.
[b]Interpolated from projections for Units 1-4.
[c]Reported in Tampa Electric Company (1980c).

Table 6-37. Monthly RIS impingement estimates for four Big Bend units at 100 percent flow capacity

Species	1979										1980		
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Total
Penaeus duorarum	1,512	2,702	1,294	2,796	12,588	21,688	27,480	14,100	8,556	4,008	920	716	98,360
Callinectes sapidus	3,282	450	314	408	436	60	204	62	512	1,786	3,410	6,140	17,064
Menippe mercenaria	0	14	48	24	32	8	88	144	146	246	36	0	786
Harengula jaguana	72	36	0	0	0	8	60	44	0	0	0	0	220
Anchoa mitchilli	986	394	242	420	30	78	356	976	2,384	3,516	732	516	10,630
Menidia beryllina	0	0	0	0	0	0	0	0	0	0	0	0	0
Bairdiella chrysoura	150	50	6,464	12,756	3,022	1,174	1,536	710	1,148	2,142	202	90	29,444
Cynoscion nebulosus	104	0	0	0	0	8	48	0	22	34	0	68	284
Pogonias cromis	0	0	0	24	32	0	0	0	0	0	0	0	56

Table 6-38. Operational data on condenser cooling water and dilution pumps for Big Bend Units 1-3, January 1976-March 1977[a]

Month	Condenser cooling-water pumps Unit 1	Unit 2	Unit 3	Total of all three units	Dilution pump
1976					
January	2.00	29.16	(b)	31.16	6.83
February	0.00	27.58	(b)	27.58	0.00
March	0.44	30.51	(b)	30.95	15.33
April	12.28	29.75	(b)	42.03	27.00
May	30.11	5.00	22.54	57.65	28.50
June	28.70	0.00	28.12	56.85	23.00
July	30.24	21.95	26.83	79.02	31.00
August	27.62	29.47	18.57	75.66	28.00
September	25.26	27.51	28.69	81.46	20.83
October	29.89	30.88	25.45	86.22	31.00
November	24.45	24.25	18.33	67.03	15.33
December	28.62	30.87	28.98	88.47	31.00
Total	239.61	286.93	197.51	724.05	257.82
1977					
January	29.41	25.95	27.73	83.09	27.83
February	27.69	25.93	15.04	68.66	22.83
March	30.20	30.67	0.00	60.87	26.83

[a]All values are days of operation.
[b]Not in service.

Table 6-39. Estimated number of total fish eggs and larvae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Eggs: Condenser entrainment	Eggs: Dilution pump entrainment	Larvae: Condenser entrainment	Larvae: Dilution pump entrainment
1976				
January	0	0	2.217×10^{6}	5.940×10^{5}
February	3.069×10^{7}	0	3.022×10^{6}	0
March	2.709×10^{8}	1.817×10^{10}	5.342×10^{7}	1.873×10^{9}
April	3.996×10^{10}	3.395×10^{10}	5.234×10^{9}	3.458×10^{9}
May	3.295×10^{10}	3.246×10^{10}	4.476×10^{9}	2.502×10^{9}
June	7.092×10^{9}	8.126×10^{9}	1.161×10^{9}	5.926×10^{8}
July	4.442×10^{9}	7.029×10^{9}	4.764×10^{9}	3.197×10^{9}
August	6.052×10^{8}	3.599×10^{8}	6.290×10^{9}	6.325×10^{8}
September	2.803×10^{8}	6.689×10^{7}	3.434×10^{9}	2.939×10^{8}
October	4.592×10^{7}	0	6.191×10^{8}	3.266×10^{7}
November	9.646×10^{5}	8.172×10^{4}	1.312×10^{7}	6.136×10^{6}
December	2.994×10^{5}	1.532×10^{4}	1.871×10^{6}	2.007×10^{6}
Total	8.568×10^{10}	1.002×10^{11}	2.596×10^{10}	1.259×10^{10}
1977				
January	0	3.581×10^{4}	2.437×10^{6}	2.937×10^{6}
February	1.648×10^{6}	4.110×10^{6}	6.914×10^{6}	4.829×10^{6}
March	1.368×10^{10}	6.925×10^{9}	1.087×10^{9}	2.756×10^{8}
Total April 1976-March 1977	9.906×10^{10}	8.892×10^{10}	2.709×10^{10}	1.100×10^{10}

[a]Adapted from Phillips et al. (1977).

Table 6-40. Estimated number of total invertebrate meroplankton entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Condenser entrainment	Dilution pump entrainment
1976		
January	5.014×10^{7}	8.178×10^{6}
February	1.119×10^{9}	0
March	9.379×10^{9}	4.843×10^{10}
April	7.191×10^{10}	8.859×10^{10}
May	8.461×10^{10}	4.800×10^{10}
June	2.346×10^{10}	1.066×10^{10}
July	4.129×10^{10}	1.410×10^{10}
August	5.286×10^{10}	8.514×10^{9}
September	1.081×10^{11}	1.277×10^{10}
October	1.177×10^{11}	1.258×10^{10}
November	2.196×10^{10}	4.629×10^{9}
December	8.873×10^{9}	1.337×10^{9}
Total	5.413×10^{11}	2.496×10^{11}
1977		
January	2.652×10^{9}	1.237×10^{9}
February	8.759×10^{9}	4.110×10^{9}
March	1.162×10^{10}	5.453×10^{9}

[a]Adapted from Blanchet, Avery, and Leverone (1977).

Table 6-41. Estimated entrainment of fish eggs, grouped by family, within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system at Big Bend Station, January-December 1976[a]

Taxon	Number of eggs entrained	Percentage of total eggs entrained
Sciaenidae (drum)	1.2×10^{11}	67
Engraulidae (anchovy)	5.795×10^{10}	31
Clupeidae (herring)	7.464×10^{8}	0.4
Carangidae (jacks/pompano)	5.452×10^{8}	0.2
Soleidae (soles)	1.171×10^{8}	0.06
Triglidae (searobins)	3.782×10^{7}	0.02
Cyprinodontidae (killifish)	1.780×10^{7}	0.01
Ephippidae (spadefish)	1.757×10^{7}	0.009
Pomadasyidae (grunts)	1.201×10^{7}	0.006
Unidentified	5.782×10^{6}	0.003
Belonidae (needlefish)	1.468×10^{6}	0.0008
Gobiidae (gobies)	3.683×10^{5}	0.0002
Atherinidae (silversides)	2.286×10^{5}	0.0001

[a]Adapted from U.S. Environmental Protection Agency (1980).

Table 6-42. Estimated entrainment of fish larvae, grouped by family, within the condenser cooling system of Units 1, 2, and 3 and the dilution pumping system at Big Bend Station, January-December 1976[a]

Taxon	Number of larvae entrained	Percentage of total larvae entrained
Engaulidae (anchovies)	3.352×10^{10}	87
Gobiidae (gobies)	1.613×10^{9}	4
Sciaenidae (drum)	1.3×10^{9}	3
Pomadasyidae (grunts)	9.052×10^{8}	2
Sparidae (porgies)	6.028×10^{8}	2
Carangidae (jacks/pompano)	3.541×10^{8}	1
Blennidae (blennies)	1.756×10^{8}	0.5
Clupeidae (herring)	7.408×10^{7}	0.2
Soleidae (soles)	9.546×10^{7}	0.2
Atherinidae (silversides)	7.569×10^{7}	0.2
Unidentified	8.352×10^{7}	0.2
Triglidae (searobins)	4.006×10^{7}	0.1
Gobiesocidae (clingfish)	2.290×10^{7}	0.06
Syngnathidae (pipefish/seahorse)	2.746×10^{6}	0.007
Tetraodontidae (puffers)	1.517×10^{6}	0.004
Cynoglossidae (tonguefish)	9.062×10^{5}	0.002
Ephippidae (spadefish)	3.674×10^{5}	0.001
Cyprinodontidae (killifish)	2.286×10^{5}	0.0006

[a]Adapted from U.S. Environmental Protection Agency (1980).

Table 6-43. Estimated number of eggs and larvae of *Anchoa mitchilli* entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Eggs		Larvae	
	Condenser entrainment	Dilution pump entrainment	Condenser entrainment	Dilution pump entrainment
1976				
January	0	0	0	0
February	2.582×10^{7}	0	0	0
March	2.398×10^{8}	3.757×10^{9}	1.949×10^{6}	1.659×10^{9}
April	9.579×10^{9}	7.245×10^{9}	4.614×10^{9}	3.044×10^{9}
May	1.350×10^{10}	1.141×10^{10}	3.950×10^{9}	1.828×10^{9}
June	3.429×10^{9}	3.168×10^{9}	9.439×10^{8}	4.089×10^{8}
July	1.673×10^{9}	3.414×10^{9}	4.197×10^{9}	2.901×10^{9}
August	1.613×10^{8}	1.960×10^{8}	5.934×10^{9}	5.426×10^{8}
September	9.298×10^{7}	3.338×10^{7}	2.902×10^{9}	2.103×10^{8}
October	2.672×10^{7}	0	3.689×10^{8}	1.487×10^{7}
November	0	0	8.343×10^{5}	1.447×10^{6}
December	0	0	0	0
Total	2.873×10^{10}	2.922×10^{10}	2.291×10^{10}	1.061×10^{10}
1977				
January	0	0	0	0
February	0	1.306×10^{5}	0	0
March	1.362×10^{10}	6.885×10^{9}	1.036×10^{9}	2.578×10^{8}

[a]Adapted from Phillips et al. (1977).

These totals match Q-dns

Table 6-44. Estimated number of eggs and larvae of Sciaenidae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Eggs		Larvae	
	Condenser entrainment	Dilution pump entrainment	Condenser entrainment	Dilution pump entrainment
1976				
January	0	0	0	0
February	4.471×10^{6}	0	0	0
March	3.062×10^{7}	1.438×10^{10}	2.784×10^{5}	8.110×10^{7}
April	3.024×10^{6}	2.661×10^{10}	1.837×10^{8}	1.530×10^{8}
May	1.863×10^{10}	2.028×10^{10}	1.339×10^{8}	1.758×10^{8}
June	3.490×10^{9}	4.582×10^{9}	3.508×10^{7}	3.733×10^{7}
July	2.681×10^{9}	3.468×10^{9}	1.083×10^{8}	1.538×10^{8}
August	4.316×10^{8}	1.601×10^{8}	1.138×10^{8}	3.164×10^{7}
September	1.854×10^{8}	3.272×10^{7}	4.094×10^{7}	1.262×10^{7}
October	1.779×10^{7}	0	5.852×10^{6}	1.792×10^{6}
November	9.646×10^{5}	8.172×10^{4}	0	0
December	2.994×10^{5}	1.532×10^{4}	0	0
Total	5.571×10^{10}	6.951×10^{10}	6.219×10^{8}	6.471×10^{8}
1977				
January	0	3.581×10^{4}	2.437×10^{6}	3.581×10^{4}
February	1.648×10^{6}	3.979×10^{6}	1.171×10^{6}	1.909×10^{5}
March	5.587×10^{7}	3.856×10^{7}	7.511×10^{6}	4.546×10^{6}

[a]Adapted from Phillips et al. (1977).

Table 6-45. Estimated number of eggs and larvae of _Harengula jaguana_ entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

	Eggs		Larvae	
Month	Condenser entrainment	Dilution pump entrainment	Condenser entrainment	Dilution pump entrainment
1976				
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	1.719×10^{7}	3.983×10^{6}	3.948×10^{6}	1.945×10^{5}
May	5.113×10^{8}	8.232×10^{7}	3.352×10^{6}	4.019×10^{6}
June	2.980×10^{7}	8.958×10^{6}	1.342×10^{6}	7.575×10^{6}
July	4.186×10^{7}	4.923×10^{7}	1.629×10^{7}	3.524×10^{7}
August	0	0	0	0
September	0	0	0	0
October	0	0	0	0
November	0	0	0	0
December	0	0	0	
Total	6.002×10^{8}	1.445×10^{8}	2.493×10^{7}	4.703×10^{7}
1977				
January	0	0	0	0
February	0	0	0	
March	0	0	0	0

[a]Adapted from Phillips et al. (1977).

Table 6-46. Estimated number of <u>Pinnixa sayana</u> larvae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Condenser entrainment	Dilution pump entrainment
1976		
January	0	0
February	5.516×10^{7}	0
March	4.660×10^{9}	1.453×10^{10}
April	3.728×10^{10}	2.661×10^{10}
May	1.701×10^{10}	1.504×10^{10}
June	1.048×10^{10}	3.330×10^{9}
July	2.623×10^{10}	7.171×10^{9}
August	1.689×10^{10}	2.138×10^{9}
September	3.945×10^{10}	2.677×10^{9}
October	8.028×10^{10}	7.078×10^{9}
November	2.475×10^{9}	1.629×10^{9}
December	7.566×10^{7}	7.830×10^{6}
Total	2.349×10^{11}	8.021×10^{10}
1977		
January	0	0
February	4.533×10^{9}	1.850×10^{9}
March	6.387×10^{9}	2.606×10^{9}

[a]Adapted from Blanchet, Avery, and Leverone (1977).

Table 6-47. Estimated number of *Polyonyx gibbesi* larvae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Condenser entrainment	Dilution pump entrainment
1976		
January	1.841×10^{6}	0
February	1.024×10^{7}	0
March	1.770×10^{9}	2.551×10^{10}
April	1.076×10^{10}	4.646×10^{10}
May	4.765×10^{10}	2.105×10^{10}
June	5.653×10^{9}	3.757×10^{9}
July	3.724×10^{9}	1.117×10^{9}
August	8.849×10^{8}	2.138×10^{8}
September	2.208×10^{10}	4.134×10^{8}
October	1.026×10^{10}	6.877×10^{8}
November	6.640×10^{9}	1.686×10^{8}
December	1.071×10^{7}	5.860×10^{6}
Total	1.094×10^{11}	9.938×10^{10}
1977		
January	0	1.446×10^{6}
February	0	4.900×10^{5}
March	0	2.961×10^{5}

[a]Adapted from Blanchet, Avery, and Leverone (1977).

Table 6-48. Estimated number of *Upogebia affinis* larvae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Condenser entrainment	Dilution pump entrainment
1976		
January	0	0
February	0	0
March	7.748×10^{8}	3.951×10^{9}
April	1.082×10^{10}	7.365×10^{9}
May	1.220×10^{10}	6.750×10^{9}
June	3.296×10^{9}	1.501×10^{9}
July	2.167×10^{9}	1.498×10^{9}
August	6.889×10^{9}	7.896×10^{8}
September	7.352×10^{9}	1.160×10^{9}
October	1.095×10^{9}	3.494×10^{8}
November	3.455×10^{7}	3.669×10^{7}
December	8.939×10^{6}	5.140×10^{6}
Total	4.464×10^{10}	2.341×10^{10}
1977		
January	0	2.892×10^{5}
February	2.963×10^{7}	3.523×10^{6}
March	4.174×10^{7}	4.885×10^{6}

[a]Adapted from Blanchet, Avery, and Leverone (1977).

Table 6-49. Estimated number of *Neopanope texana* larvae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Condenser entrainment	Dilution pump entrainment
1976		
January	0	0
February	0	0
March	1.668×10^{8}	3.736×10^{8}
April	9.108×10^{8}	6.851×10^{8}
May	6.235×10^{8}	4.061×10^{8}
June	1.381×10^{9}	2.958×10^{8}
July	9.172×10^{8}	4.686×10^{8}
August	1.221×10^{10}	1.138×10^{9}
September	1.294×10^{10}	2.686×10^{9}
October	1.147×10^{10}	1.409×10^{9}
November	1.037×10^{9}	5.215×10^{8}
December	2.534×10^{8}	1.035×10^{8}
Total	4.191×10^{10}	8.087×10^{9}
1977		
January	2.728×10^{6}	1.879×10^{6}
February	8.786×10^{7}	3.335×10^{7}
March	1.231×10^{8}	4.648×10^{7}

[a]Adapted from Blanchet, Avery, and Leverone (1977).

Table 6-50. Estimated number of *Menippe mercenaria* larvae entrained within the condenser cooling system of Units 1, 2, and 3 and within the dilution pumping system of Big Bend Station, January 1976-March 1977[a]

Month	Condenser entrainment	Dilution pump entrainment
1976		
January	0	0
February	0	0
March	6.453×10^7	1.779×10^8
April	5.642×10^8	3.237×10^8
May	2.782×10^8	1.416×10^8
June	3.485×10^9	1.748×10^8
July	5.306×10^8	3.579×10^8
August	1.025×10^9	2.105×10^8
September	1.742×10^9	4.965×10^8
October	4.529×10^8	9.596×10^7
November	1.585×10^7	9.525×10^6
December	9.729×10^5	1.059×10^6
Total	5.023×10^9	1.989×10^9
1977		
January	0	0
February	0	0
March	0	0

[a]Adapted from Blanchet, Avery, and Leverone (1977).

Table 6-51. Monthly RIS entrainment estimates for four Big Bend Units at 100 percent flow capacity

Species and life stage	1979										1980	
	March	April	May	June	July	August	September	October	November	December	January	February
Penaeus duorarum												
Postlarvae	0	0	0	1.27×10^5	3.39×10^6	2.25×10^6	8.79×10^6	4.07×10^6	0	0	0	0
Callinectes sapidus	0	0	0	0	0	0	0	0	0	0	0	0
Menippe mercenaria												
Stage 1 zoea	1.18×10^7	3.32×10^8	7.89×10^8	6.04×10^8	4.58×10^8	5.14×10^7	8.79×10^6	6.73×10^5	9.60×10^5	5.37×10^5	6.08×10^3	1.83×10^4
Stage 2 zoea	2.09×10^5	2.19×10^6	1.68×10^7	4.84×10^7	5.38×10^7	3.24×10^6	2.06×10^5	0	0	0	0	0
Stage 3 zoea	0	0	2.93×10^6	1.21×10^7	1.70×10^7	1.66×10^5	1.20×10^5	0	0	0	0	0
Stage 4 zoea	0	5.40×10^4	4.17×10^5	1.60×10^6	2.17×10^6	1.16×10^5	8.34×10^4	0	0	0	0	0
Stage 5 zoea	0	0	5.94×10^4	7.76×10^5	2.81×10^6	0	0	0	0	0	0	0
Anchoa mitchilli												
Eggs	4.29×10^9	8.90×10^9	1.82×10^{10}	2.43×10^{10}	2.88×10^{10}	1.08×10^{10}	7.88×10^8	8.35×10^7	0	0	2.41×10^5	2.01×10^8
Prolarvae	2.30×10^8	1.72×10^8	2.21×10^8	2.24×10^8	1.47×10^8	4.74×10^7	6.19×10^6	1.15×10^6	0	0	0	7.68×10^6
Postlarvae	3.62×10^8	1.33×10^9	1.76×10^9	3.11×10^9	3.06×10^9	3.10×10^8	1.01×10^8	2.43×10^7	4.11×10^5	5.96×10^4	0	1.23×10^6
Harengula jaguana												
Eggs	0	0	1.88×10^7	3.59×10^7	4.94×10^6	0	0	0	0	0	0	0
Prolarvae	0	0	3.77×10^8	6.38×10^8	4.04×10^8	0	0	0	0	0	0	0
Postlarvae	0	1.94×10^5	4.21×10^7	1.39×10^8	1.58×10^8	0	0	0	0	0	0	0
Menidia beryllina												
Eggs	0	0	0	0	0	0	0	0	0	0	0	0
Prolarvae	0	0	0	0	0	0	0	0	0	0	0	0
Postlarvae	2.80×10^5	3.62×10^5	5.46×10^5	3.39×10^5	0	0	0	0	0	3.47×10^4	3.97×10^4	0
Bairdiella chrysoura												
Eggs	3.47×10^7	1.55×10^9	6.35×10^9	2.12×10^7	7.50×10^8	1.37×10^8	8.38×10^5	0	0	0	5.45×10^5	1.36×10^6
Prolarvae	3.56×10^6	2.46×10^6	7.10×10^6	2.95×10^6	4.43×10^4	0	0	0	0	0	0	1.50×10^5
Postlarvae	1.08×10^6	4.55×10^6	7.06×10^6	2.23×10^6	1.74×10^5	0	0	0	0	0	0	2.16×10^4
Cynoscion nebulosus												
Eggs	0	0	0	0	0	0	0	0	0	0	0	0
Prolarvae	0	0	0	1.27×10^5	1.70×10^5	0	0	0	0	0	0	0
Postlarvae	2.39×10^5	3.23×10^5	1.88×10^6	1.75×10^6	1.31×10^6	1.04×10^5	3.02×10^5	7.54×10^4	0	0	0	0
Unidentified *Cynoscion*												
Eggs	3.10×10^5	6.30×10^6	2.19×10^7	3.43×10^5	0	0	0	0	0	0	8.01×10^4	1.88×10^4
Prolarvae	1.34×10^5	6.35×10^4	0	0	0	0	0	0	0	0	1.02×10^5	1.70×10^5
Postlarvae	0	0	0	0	0	0	0	0	0	0	0	0
Pogonias cromis												
Eggs	3.40×10^4	7.29×10^6	3.36×10^7	6.06×10^5	0	0	0	0	0	6.5×10^4	6.94×10^5	0
Prolarvae	5.05×10^5	2.43×10^6	2.20×10^6	1.17×10^6	2.73×10^5	1.43×10^5	0	0	0	0	0	9.65×10^3
Postlarvae	6.24×10^5	1.93×10^6	1.50×10^5	0	0	0	0	0	0	0	0	0
Unidentified sciaenid												
Eggs	1.89×10^8	9.77×10^9	3.30×10^{10}	2.21×10^{10}	1.50×10^{10}	2.50×10^9	2.10×10^7	1.76×10^6	3.83×10^5	0	1.20×10^6	1.48×10^6
Prolarvae	4.04×10^5	2.81×10^5	8.69×10^5	8.31×10^5	1.45×10^5	5.49×10^5	0	0	0	0	4.86×10^4	8.11×10^4
Postlarvae	0	0	0	0	0	0	0	0	0	0	0	0

Table 6-52. Viability of fish eggs impinged on the prototype fine-mesh screen at Big Bend Station, March-August 1980[a,b]

Taxon	Initial survival			Hatchability			48-hour survival of hatched egg			96-hour survival of hatched egg		
	Number of observations	Mean[c]	Standard error	Number of observations	Mean[c]	Standard error	Number of observations	Mean[c]	Standard error	Number of observations	Mean[c]	Standard error
Clupeiformes	327 (16)	0.432 (0.855)	0.014 (0.028)	322 (20)	0.810 (0.893)	0.007 (0.032)	322 (20)	0.844 (0.903)	0.006 (0.021)	322 (20)	0.624 (0.686)	0.016 (0.059)
Harengula jaguana	69 (8)	0.458 (0.996)	0.044 (0.002)	71 (8)	0.929 (0.985)	0.013 (0.009)	71 (8)	0.828 (0.922)	0.030 (0.033)	71 (8)	0.459 (0.276)	0.044 (0.133)
Anchoa mitchilli	320 (16)	0.433 (0.850)	0.015 (0.027)	314 (20)	0.800 (0.886)	0.007 (0.032)	314 (20)	0.839 (0.900)	0.007 (0.022)	314 (20)	0.637 (0.720)	0.015 (0.052)
Sciaenidae	268 (13)	0.753 (0.984)	0.017 (0.130)	283 (18)	0.948 (0.990)	0.006 (0.003)	283 (18)	0.843 (0.913)	0.012 (0.039)	283 (18)	0.697 (0.827)	0.018 (0.049)
Bairdiella chrysoura	175 (6)	1.000 (1.000)	0.000 (0.000)	195 (10)	1.000 (1.000)	0.000 (0.000)	195 (10)	0.991 (0.994)	0.003 (0.004)	195 (20)	0.979 (0.978)	0.006 (0.016)
Cynoscion spp.	135 (12)	1.000 (1.000)	0.000 (0.000)	184 (17)	1.000 (1.000)	0.000 (0.000)	184 (17)	0.994 (0.993)	0.003 (0.007)	184 (17)	0.894 (0.969)	0.019 (0.021)
Menticirrhus spp.	183 (11)	1.000 (1.000)	0.000 (0.000)	221 (14)	1.000 (1.000)	0.000 (0.000)	221 (14)	0.997 (1.000)	0.002 (0.000)	221 (14)	0.884 (0.915)	0.020 (0.071)
Pogonias cromis	14 (--)	1.000 (--)	0.000 (--)	17 (--)	1.000 (--)	0.000 (--)	17 (--)	0.882 (--)	0.081 (--)	17 (--)	0.853 (--)	0.083 (--)

[a]Adapted from Tampa Electric Company (1980d).
[b]Numbers in parentheses are data for control organisms. A dash denotes no observation.
[c]Proportion surviving.

Table 6-53. Viability of fish larvae impinged on the prototype fine-mesh screen at Big Bend Station, March-August 1980[a,b]

Taxon	Initial survival: Number of observations	Initial survival: Mean[c]	Initial survival: Standard error	48-hour survival: Number of observations	48-hour survival: Mean[c]	48-hour survival: Standard error	96-hour survival: Number of observations	96-hour survival: Mean[c]	96-hour survival: Standard error
Clupeiformes	278 (11)	0.015 (0.104)	0.006 (0.035)	11 (1)	0.364 (0.000)	0.152 (0.000)	11 (1)	0.364 (0.000)	0.152 (0.000)
Harengula jaguana	15 (--)	0.000 (--)	0.000 (--)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)
Anchoa mitchilli	274 (10)	0.015 (0.114)	0.007 (0.037)	9 (1)	0.222 (0.000)	0.147 (0.000)	9 (1)	0.222 (0.000)	0.147 (0.000)
Sciaenidae	108 (6)	0.186 (0.444)	0.035 (0.205)	26 (1)	0.109 (0.000)	0.050 (0.000)	26 (1)	0.101 (0.000)	0.048 (0.000)
Bairdiella chrysoura	39 (2)	0.192 (0.500)	0.060 (0.500)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)
Cynoscion spp.	51 (1)	0.157 (0.000)	0.051 (0.000)	3 (--)	1.000 (--)	0.000 (0.000)	3 (--)	1.000 (--)	0.000 (--)
Menticirrhus spp.	15 (4)	0.000 (0.250)	0.000 (0.250)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)
Pogonias cromis	7 (1)	0.429 (1.000)	0.202 (0.000)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)	-- (--)

[a]Adapted from Tampa Electric Company (1980d).
[b]Numbers in parentheses are data for control organisms. A dash denotes no observation.
[c]Proportion surviving.

Table 6-54. Viability of the zoeal stages of various decapod crustacean macroinvertebrates impinged on the prototype fine-mesh screen at Big Bend Station, March-August 1980[a,b]

Taxon	Initial survival: Number of observations	Initial survival: Mean[c]	Initial survival: Standard error	48-hour survival: Number of observations	48-hour survival: Mean[c]	48-hour survival: Standard error	96-hour survival: Number of observations	96-hour survival: Mean[c]	96-hour survival: Standard error
Caridea	195 (10)	0.943 (0.767)	0.013 (0.132)	185 (8)	0.850 (0.868)	0.015 (0.083)	185 (8)	0.500 (0.438)	0.024 (0.126)
Upogebia affinis	221 (13)	0.913 (0.756)	0.016 (0.107)	194 (11)	0.841 (0.762)	0.014 (0.117)	194 (11)	0.428 (0.454)	0.027 (0.124)
Paguridae	111 (2)	0.949 (1.000)	0.020 (0.000)	85 (3)	0.966 (1.000)	0.017 (0.000)	85 (3)	0.792 (0.333)	0.039 (0.333)
Brachyura	335 (14)	0.955 (0.650)	0.005 (0.107)	238 (9)	0.839 (0.556)	0.019 (0.176)	238 (9)	0.459 (0.278)	0.026 (0.147)
Xanthidae	333 (--)	0.991 (--)	0.003 (--)	325 (19)	0.959 (0.956)	0.004 (0.013)	325 (19)	0.749 (0.734)	0.015 (0.065)
Menippe mercenaria	235 (11)	0.979 (0.973)	0.005 (0.018)	189 (12)	0.915 (0.949)	0.014 (0.025)	189 (12)	0.583 (0.610)	0.028 (0.126)
Pinnotheridae	292 (11)	1.000 (1.000)	0.000 (0.000)	293 (14)	0.922 (0.934)	0.009 (0.034)	293 (14)	0.730 (0.721)	0.018 (0.080)
Grapsizoea	228 (13)	1.000 (1.000)	0.000 (0.000)	229 (16)	0.951 (0.979)	0.008 (0.010)	229 (16)	0.802 (0.929)	0.017 (0.024)

[a]Adapted from Tampa Electric Company (1980d).
[b]Numbers in parentheses are data for control organisms. A dash denotes no observation.
[c]Proportion surviving.

Table 6-55. Viability of the megalops stage of various decapod crustacean macroinvertebrates impinged on the prototype fine-mesh screen at Big Bend Station, March-August 1980[a,b]

Taxon	Initial survival			48-hour survival			96-hour survival		
	Number of observations	Mean[c]	Standard error	Number of observations	Mean[c]	Standard error	Number of observations	Mean[c]	Standard error
Caridea	1 (--)	1.000 (--)	0.000 (--)	1 (--)	1.000 (--)	0.000 (--)	1 (--)	1.000 (--)	0.000 (--)
Upogebia affinis	67 (1)	1.000 (1.000)	0.000 (0.000)	97 (1)	0.977 (1.000)	0.010 (0.000)	97 (1)	0.743 (1.000)	0.039 (0.000)
Paguridae	5 (--)	1.000 (--)	0.000 (--)	10 (--)	0.900 (--)	0.0001 (--)	10 (--)	0.800 (--)	0.0002 (--)
Brachyura	124 (5)	0.651 (0.267)	0.041 (0.194)	65 (--)	0.718 (--)	0.045 (--)	65 (--)	0.150 (--)	0.0003 (--)
Xanthidae	189 (4)	1.000 (1.000)	0.000 (0.000)	214 (8)	0.983 (1.000)	0.006 (0.000)	214 (8)	0.942 (0.969)	0.010 (0.031)
Menippe mercenaria	5 (--)	1.000 (--)	0.000 (--)	6 (--)	1.000 (--)	0.000 (--)	6 (--)	1.000 (--)	0.000 (--)
Pinnotheridae	19 (--)	1.000 (--)	0.000 (--)	28 (--)	1.000 (--)	0.000 (--)	28 (--)	0.929 (--)	0.050 (--)
Grapsizoea	110 (9)	1.000 (1.000)	0.000 (0.000)	179 (11)	0.981 (1.000)	0.004 (0.000)	179 (11)	0.931 (0.912)	0.008 (0.051)

[a]Adapted from Tampa Electric Company (1980d).
[b]Numbers in parentheses are data for control organisms. A dash indicates no observation.
[c]Proportion surviving.

Table 6-56. Analysis of variance in the survival of fish impinged on fine-mesh screens at Big Bend Station

Dependent variable	Total degrees of freedom	F-statistic: Temperature	Screen speed	Approach velocity	Interaction	R^2
Sciaenids						
Egg initial survival	267	16.70[a]	1.13	8.34[a]	3.16	0.132
Egg hatchability	282	21.00[a]	1.98	8.70[a]	0.50	0.119
Hatched-egg survival						
48 hr	282	35.54[a]	0.16	19.41[a]	0.06	0.165
96 hr	282	45.74[a]	1.45	14.54[a]	0.48	0.203
Larvae survival						
Initial	107	4.20[b]	0.17	0.05	0.06	0.044
48 hr	25	0.03	0.05	1.65	0.09	0.104
96 hr	25	0.00	0.13	1.74	0.12	0.119
Cynoscion spp.						
Egg initial survival[c]	134					
Egg hatchability[c]	183					
Hatched-egg survival						
48 hr	183	4.81[b]	1.32	0.00	0.94	0.045
96 hr	183	114.98[b]	1.76	0.48	0.60	0.403
Larvae survival						
Initial	50	0.60	0.48	1.05	0.03	0.064
48 hr	2[c]					
96 hr	2[c]					
Anchoa mitchilli						
Egg initial survival	319	9.39[a]	0.33	0.25	1.64	0.046
Egg hatchability	313	66.05[a]	1.84	2.18	1.33	0.200
Hatched-egg survival						
48 hr	313	0.93	0.05	1.76	0.45	0.013
96 hr	313	364.00[a]	3.16	2.43	0.62	0.552
Larvae survival						
Initial	273	3.84	1.26	0.09	0.67	0.028
48 hr	8	3.03	(d)	0.19	(d)	0.360
96 hr	8	3.03	(d)	0.19	(d)	0.360

[a]$P \leq .01$.
[b]$P \leq .05$.
[c]No variability in this dependent variable.
[d]Insufficient observations to estimate this variable.

Table 6-57. Analysis of variance in the survival of invertebrates impinged on fine-mesh screens at Big Bend Station

Dependent variable (survival)	Total degrees of freedom	F-statistic				R^2
		Temperature	Screen speed	Approach velocity	Interaction[a]	
Brachyura						
Zoea, initial	334	4.47[b]	0.68	0.15	1.37	0.025
Zoea, 48 hr	237	0.86	0.08	0.21	0.48	0.010
Zoea, 96 hr	237	36.71[c]	0.08	0.01	0.09	0.139
Megalops, initial	123	7.76[c]	1.17	0	1.10	0.093
Megalops, 48 hr	64	1.09	0.15	0.14	2.62	0.120
Megalops, 96 hr	64	14.81[c]	0.41	0.30	1.14	0.248
Xanthidae						
Zoea, initial	0					
Zoea, 48 hr	324	51.00[c]	1.34	10.09[b]	0.96	0.192
Zoea, 96 hr	324	381.38[c]	1.47	0.10	0.40	0.562
Megalops, initial[d]	188					
Megalops, 48 hr	213	3.16	0.38	0.55	1.34	0.032
Megalops, 96 hr	213	15.36[c]	0.76	0.26	0.97	0.086
<u>Mennippe mercenaria</u>						
Zoea, initial	234	17.15[c]	0.29	2.06	0.35	0.088
Zoea, 48 hr	188	5.14[b]	2.69	0.20	0.16	0.060
Zoea, 96 hr	188	124.90[b]	6.19[c]	0.95	0.49	0.456

[a]Interaction between screen speed and approach velocity.
[b]$P \leq .05$.
[c]$P \leq .01$.
[d]No variability in this dependent variable.

Table 6-58. Taxonomic groups recovered and identified in spray-wash efficiency sampling conducted at Big Bend Station during April-July 1980

Taxonomic group	Taxon
Anchoa mitchilli	*Anchoa mitchilli*[a]
Invertebrate "zoea"	Unidentified invertebrate zoea
	Caridea
	Penaeidae
	Brachyura (including the xanthid *Menippe mercenaria*[a])
	Thalassinidea
	Anomura
Perciformes	Unidentified Perciformes
	Archosargus probatocephalus
	Unidentified Carangidae
	Unidentified Sciaenidae
	Bairdiella chrysoura[a]
	Menticirrhus spp.
	Pogonias cromis[a]
	Cynoscion arenarius
	Cynoscion nebulosus[a]
	Gobiosoma rubustum
	Orthopristis chrysoptera

[a]Representative important species.

Table 6-59. Results of spray-wash efficiency testing conducted at Big Bend Station during April-July 1980

Taxonomic group	Life stage	Number of observations	Percentage of carryover Range	Mean	Mean of percentage removed
Anchoa mitchilli	Eggs	15	17-100	52.9	47.1
	Larvae	15	13-76	39.5	60.5
"Zoea"	Zoea	15	7.5-43	23.7	76.3
Perciformes	Eggs	15	26-100	52.4	47.6
	Larvae	15	0-100	42.3	57.7

Table 6-60. Taxonomic groups recovered and identified in screening efficiency sampling conducted at Big Bend Station

Taxonomic group	Taxon
Anchoa mitchilli	Anchoa mitchilli[a]
Invertebrate "zoea"	Unidentified invertebrate zoea
	Caridea
	Penaeidae
	Brachyura (including the xanthid Menippe mercenaria[a])
	Thalassinidea
	Anomura
Perciformes	Unidentified Perciformes
	Archosargus probatocephalus
	Chloroscombrus chrysurus
	Unidentified Sciaenidae
	Bairdiella chrysoura[a]
	Menticirrhus spp.
	Orthopristis chrysoptera

[a]Representative important species.

Table 6-61. Results of screening efficiency testing at Big Bend Station

Taxonomic group	Life stage	Number of observations	Percentage of loss Range	Mean
Anchoa mitchilli	Eggs	4	80.4-88.0	84.9
	Larvae	4	24.6-63.8	42.5
"Zoea"	Zoea	4	14.9-41.2	26.6
Perciformes	Eggs	4	37.8-100	69.8

Table 6-62. Taxonomic groups analyzed in flume and organism survival studies conducted at Big Bend Station from June through August 1980

Taxonomic group	Taxon
Anchoa mitchilli	Anchoa mitchilli[a]
Harengula jaguana	Harengula jaguana[a]
Perciformes	Unidentified Carangidae
	Chloroscombrus chrysurus
	Oligoplites saurus
	Orthopristis chrysoptera
	Unidentified Sciaenidae
	Bairdiella chrysoura[a]
	Cynoscion arenarius
	Cynoscion nebulosus[a]
	Menticirrhus spp.
	Pogonias cromis[a]
	Microgobius gulosus
Shrimp	Caridea
Crabs	Brachyura (primarily Pinnixa sayana)
	Xanthidae (including Menippe mercenaria[a])
	Thalassinidea (primarily Upogebia affinis)
	Anomura

[a]Representative important species.

Table 6-63. Total 48-hour species survival in flume and organism survival studies at Big Bend Station, June-August 1980

Species	Range of observed values	Mean survival	Numbers of observations of each test type included in the mean[a]
Anchoa mitchilli[b]	22.1-89.4	49.7	C(5), F(10), CR(5), CP(5)
Harengula jaguana[b]	40.0-100.0	76.2	C(3), F(5), CR(3), CP(3)
Perciformes[b]	0-79.4	42.6	C(6), F(9), CR(6), CP(6)
Shrimp[b]	37.5-100.0	69.7	C(8), F(14)
Crabs[c]	44.9-81.4	63.1	C(8), F(15)

[a]Key:
- C = Live control organisms collected from screen, placed in flume, and held in intake-canal water
- F = Live test organisms collected from screen, run in flume, and held in intake-canal water
- CR = Net-collected organisms held in organisms return-canal water
- CP = Net-collected organisms held in intake-canal water

[b]Includes eggs, yolk-sac larvae, and postlarvae.

[c]Includes all zoeal life stages.

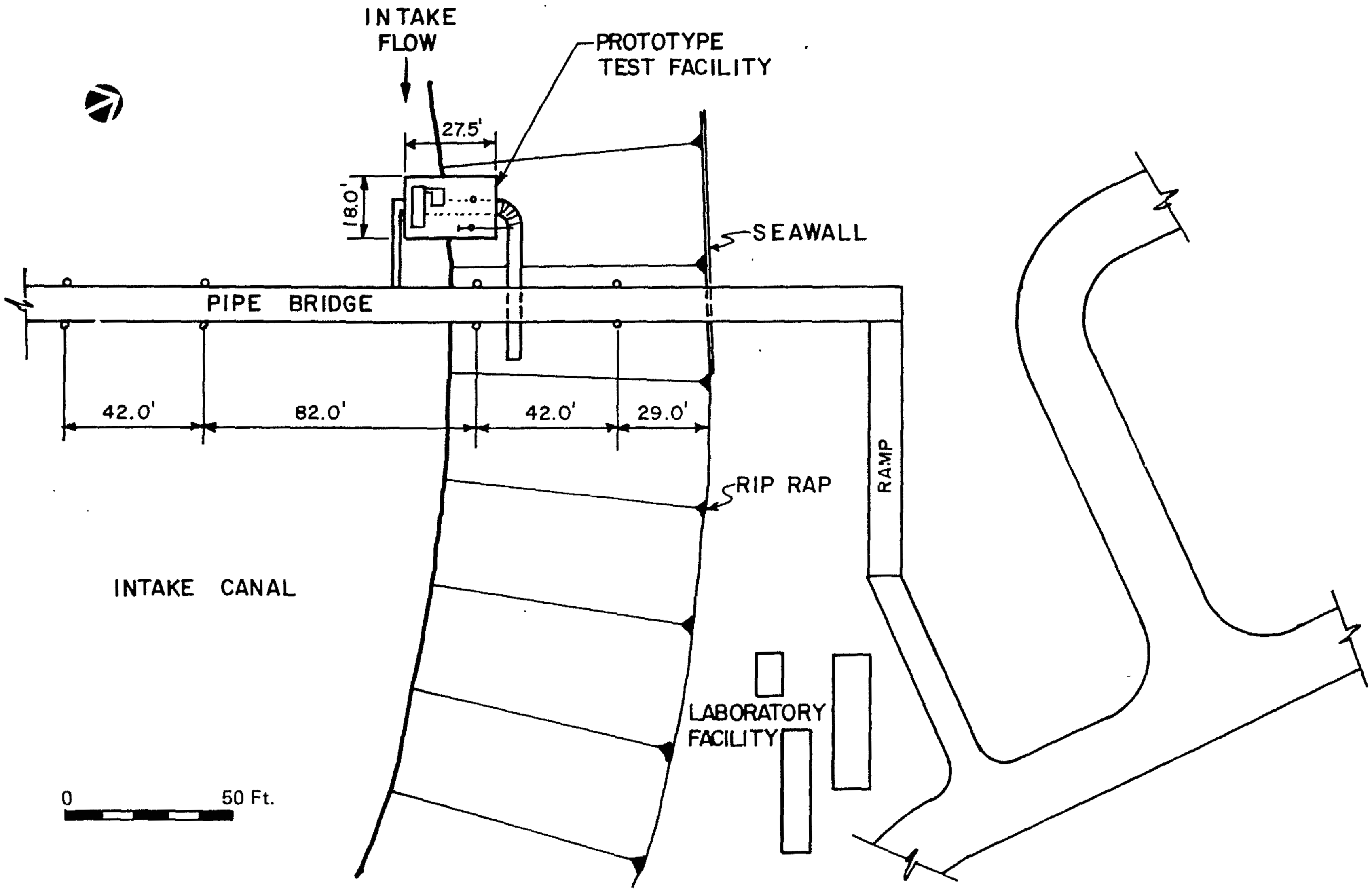

Figure 6-47. Site plan, prototype fine-mesh screen, Big Bend Station Unit 4.

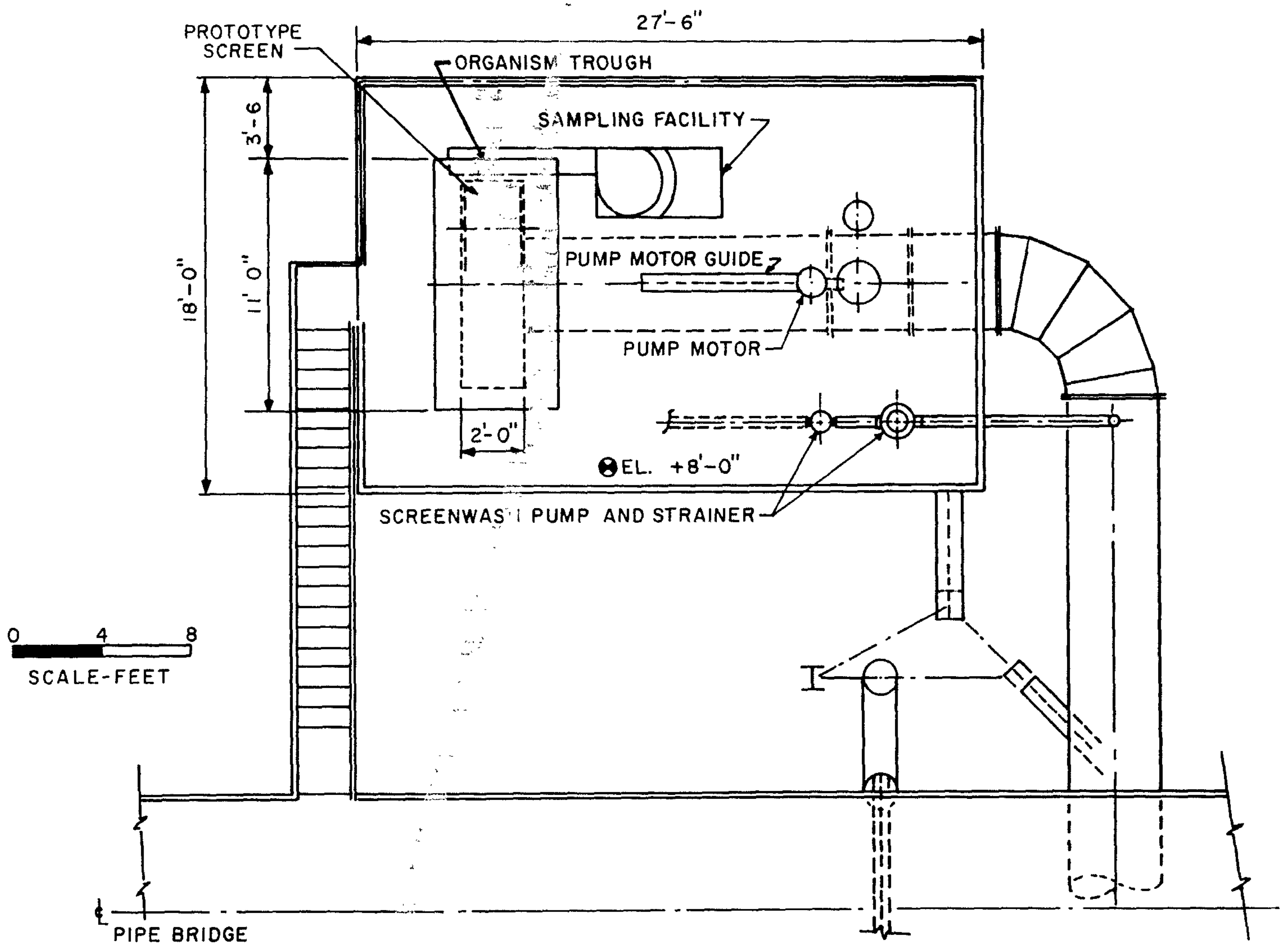

Figure 6-48. Deck arrangement, prototype fine-mesh screen, Big Bend Station Unit 4.

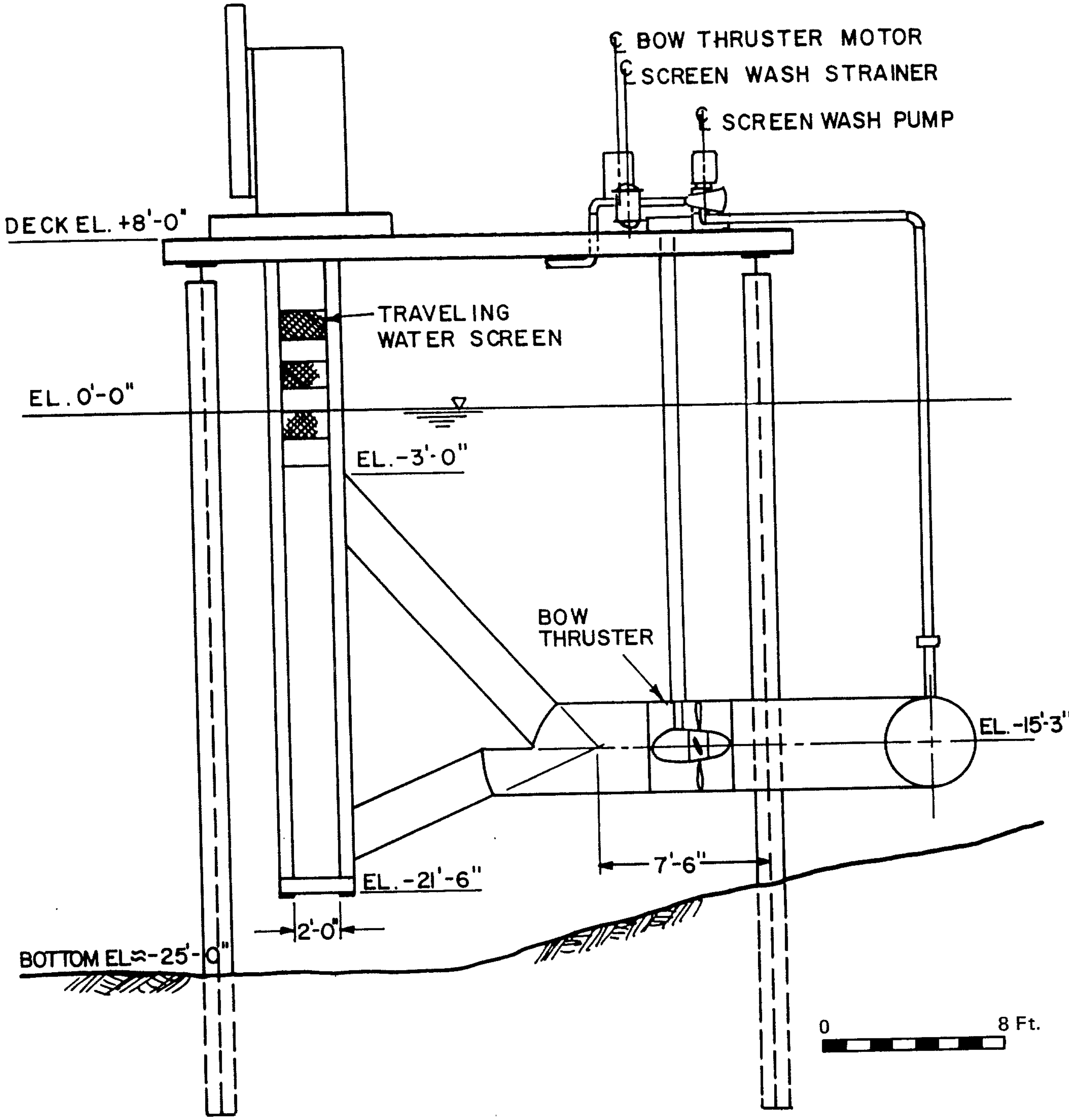

Figure 6-49. Profile arrangement, prototype fine-mesh screen, Big Bend Station Unit 4.

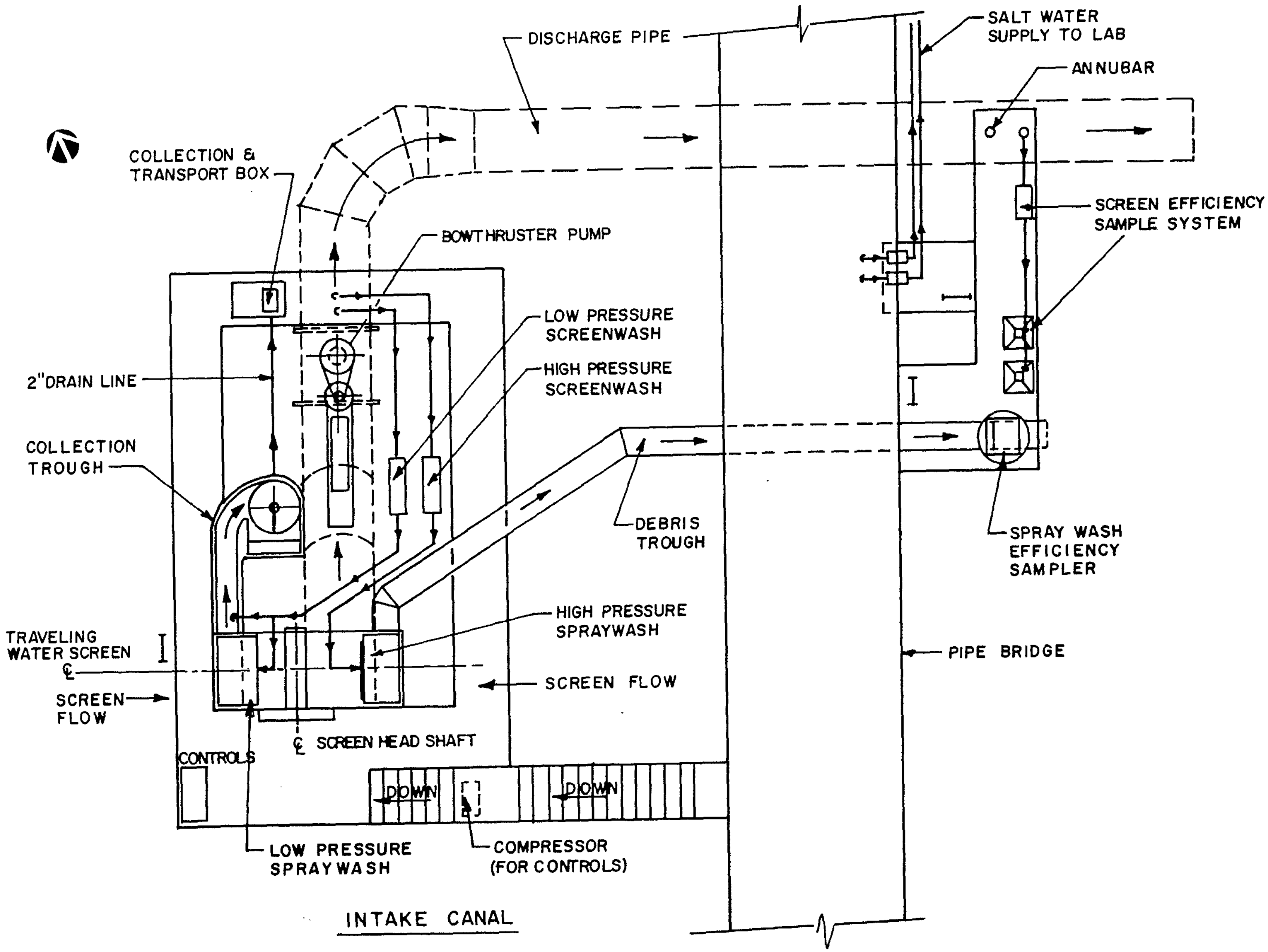

Figure 6-50. Deck arrangement for fine-mesh screen test facility, prototype fine-mesh screen, Big Bend Station Unit 4.

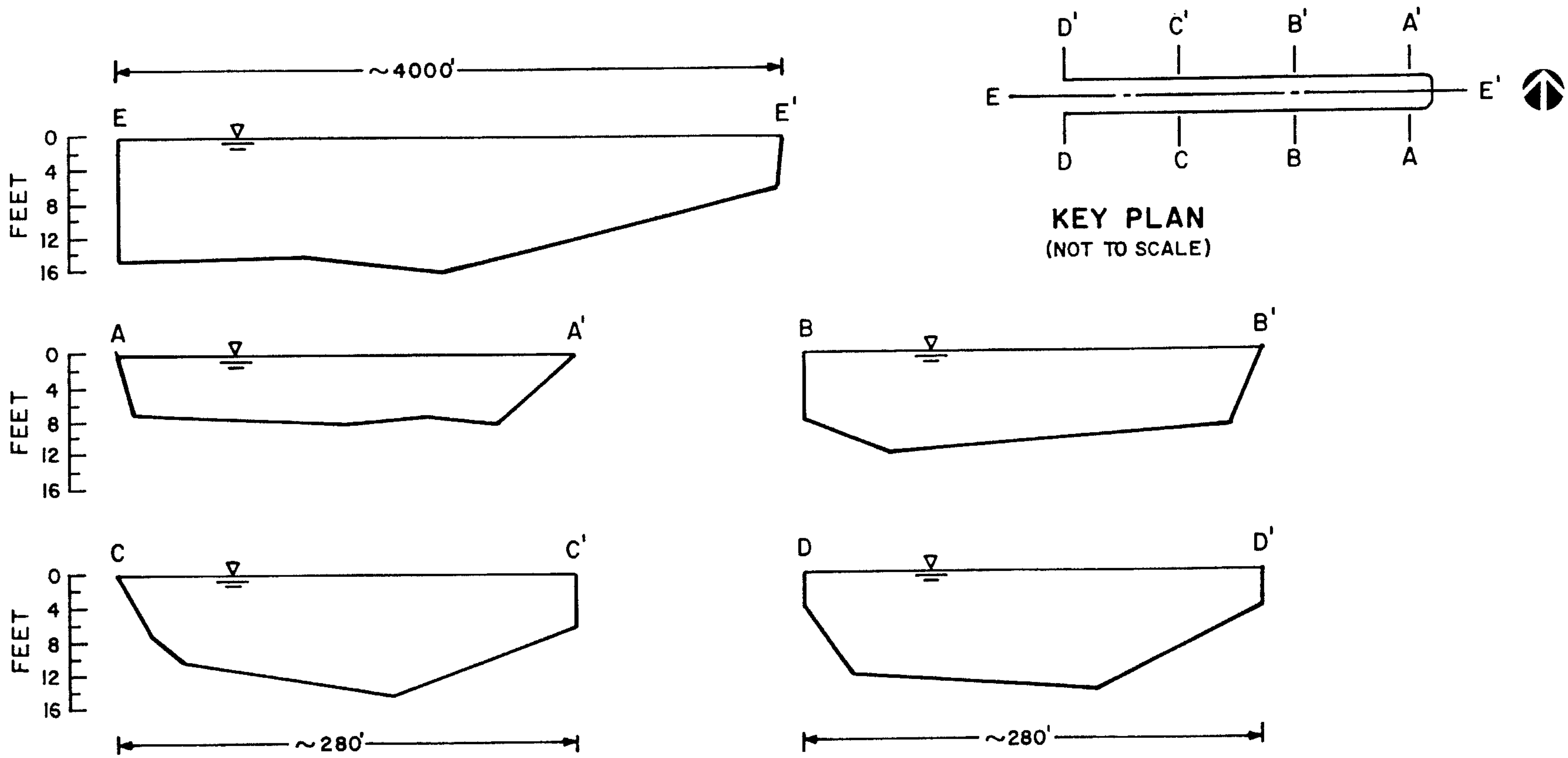

Figure 6-53. Dimensions of organism return canal.

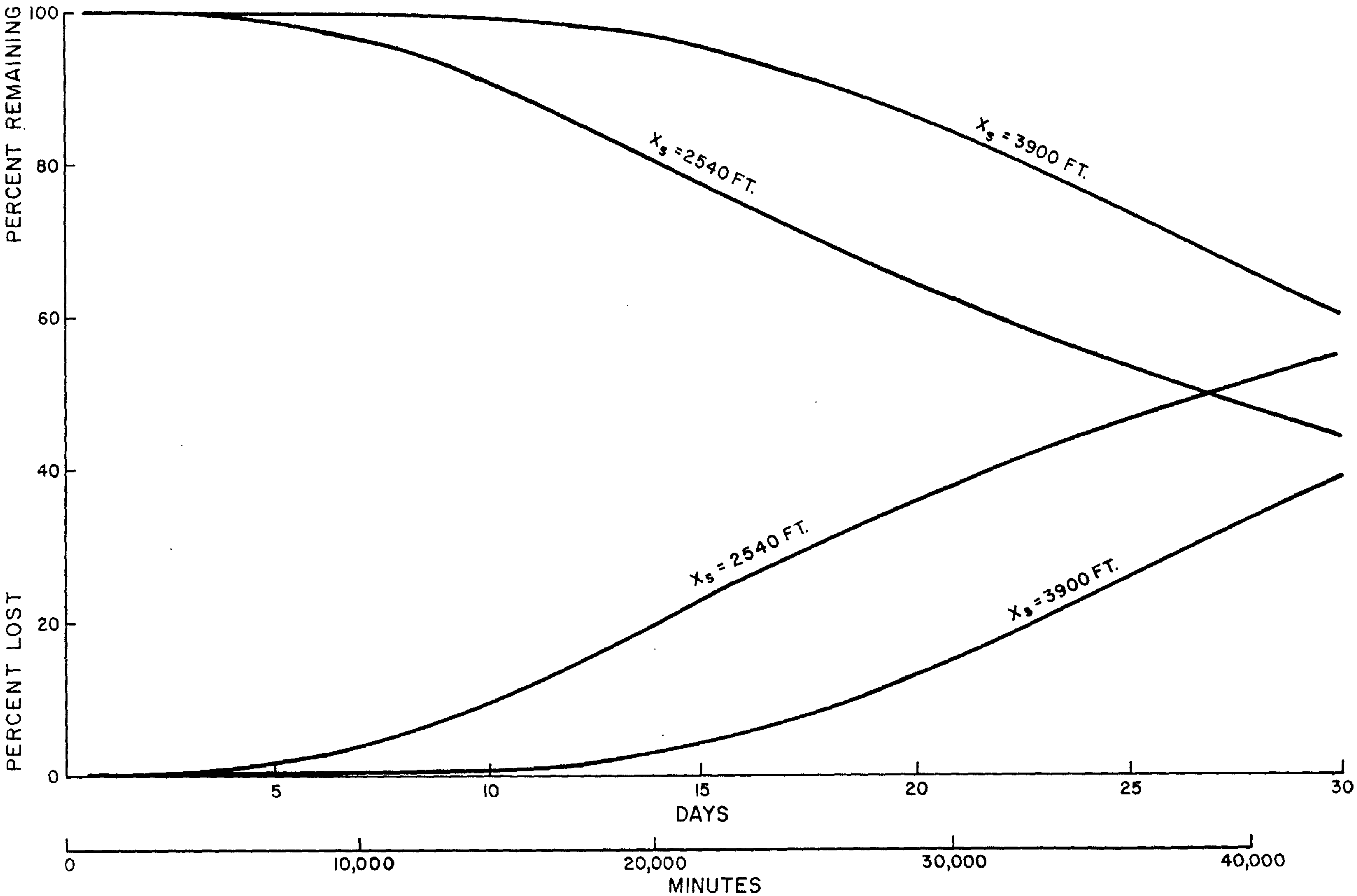

Figure 6-54. Disposal of organisms after batch release at two locations in the organism return canal, Big Bend Station.

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